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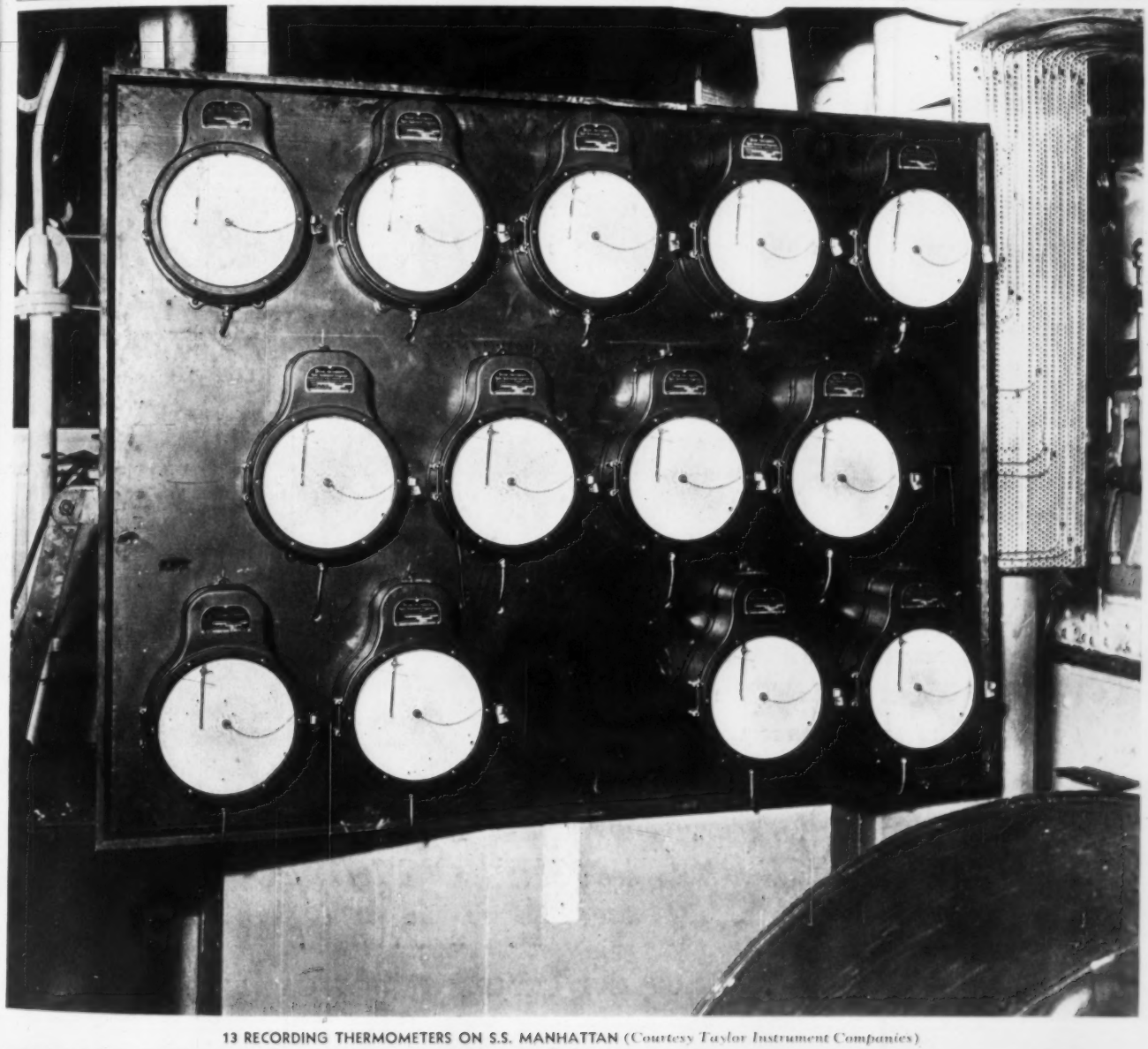
INSTRUMENTS

THE MAGAZINE OF MEASUREMENT AND CONTROL

VOLUME 5 NOVEMBER, 1932 NUMBER 11



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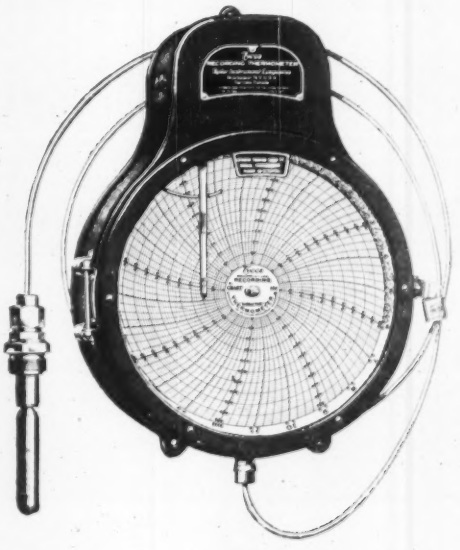

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INSTRUMENTS

THE MAGAZINE of MEASUREMENT and CONTROL

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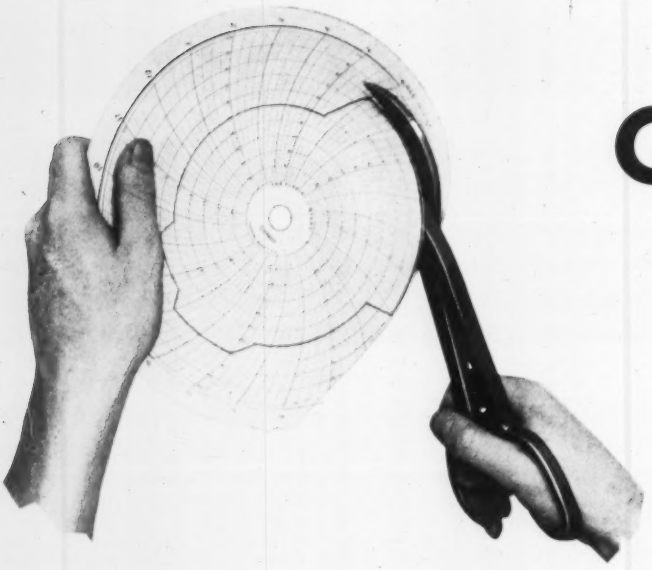

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◆ A cut aluminum cam is used on this instrument in place of the usual chart and a cam follower instead of the pen arm. With this type of construction, it is possible to obtain a 1 to 1 ratio between the cam reading and control point setting.

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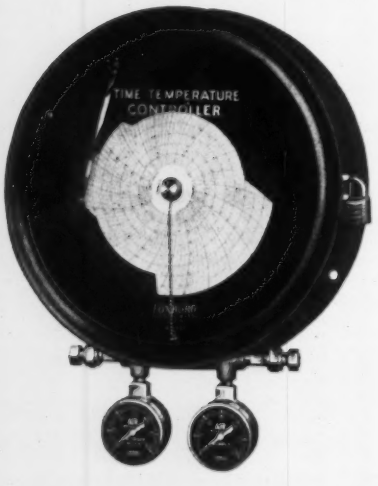

◆ Cams for the Controller can be cut from standard aluminum blanks **with a pair of shears and a file.** On processes requiring a wide variety of schedules, a supply of discs can be stocked and the cams cut on the job to meet conditions.

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EDITORIAL COMMENT

In This Issue

◆ Most of us can remember seeing men toiling all day lifting ingredients or processed materials on and off scales, and other men busy all day reading the scales and writing down the weights. **E. C. Koerper** explains how **Automatic Weight Recording** has made unnecessary such waste of time and effort.

◆ This day of high-speed engines has led to the development of appropriate **Engine Indicators** and most of these are described by **Prof. DeJuhasz** in his usual thorough way.

◆ Although he deals with both "dry" and "wet" meters, **Major Behar's** discussion of the "positive meter" question is anything but dry. He follows it with useful information, some of which is new.

◆ This month's illustrated digest of **New Instruments** presents a wide variety including laboratory as well as plant and commercial devices.

◆ **Book Reviews**, abstracts of **Current Literature**, and our usual alphabetical **Index** complete the editorial bill of fare for November.

◆ ◆ ◆

The Front Cover

◆ Special problems were successfully solved in the marine installation shown. In all, 16 mercury system recorders are used, with tubing up to 105 ft. long exposed to fluctuations of ambient temperature. Position and acceleration effects of rolling and pitching were also compensated for.

True and False Repair Economy

FROM MANY quarters we hear that in anticipation of renewed activities, those in charge of laboratory and plant instruments are having them gone over and re-conditioned. Without presuming to lay down exact rules, and certainly without intention of slowing up this excellent practice, we feel called on to mention several matters that may perhaps be overlooked.

First, do not send good dollars after bad pennies by repairing obsolete instruments, instead of replacing them by improved models at a cost which in some cases is *lower than that of repairs*. Bear in mind also that the appraisal value of a repaired device is seldom increased in proportion to the repair cost.

Whatever kind of work has to be done in your plant or laboratory, remember that "there's always somebody ready to do a poor job cheaper." Among the men who solicit your instrument repair business there are no doubt some experienced and reliable mechanics—perhaps engineers or laboratory technicians—who are unemployed through no fault of their own; but there may be some "monkey-wrench and screw driver mechanics" whose glib salesmanship conceals ignorance of instrument work.

Analyze the kinds of work to be done. Ascertain which instruments and control systems seem to require new working parts or new fittings. Segregate them from the others most of which others can probably be re-conditioned in your own plant or laboratory. Then decide in each case whether (1) to buy the replacement from the original manufacturer, (2) to buy it from the nearest instrument repair service, (3) to have it made by a nearby repair shop or (4) to make it yourself.

Where such an instrument or control system is small and light, and can conveniently be removed, *it should preferably be sent to the original manufacturer* who can of course replace the unserviceable part with an exact duplicate. There are reliable instrument repair laboratories in most large industrial centers, however, that carry authorized parts, employ high-class instrument men and turn out excellent jobs. Some of these are recommended by local representations of instrument manufacturers. Others, for various reasons, are not. Probably, there is not one such repair station which is recommended by all instrument companies.

"Bootleg parts" have appeared on the market. They "look all right" but in some cases they impair the accuracy or value of the instrument or system. For example, in the case of thermal systems, a "gyp" repair man will tell you that he can replace a certain separable socket, but he will supply one with a slightly different taper and the consequent dead air space around the bulb will cause considerable lag; or else, he will take a "500-lb." pressure-spring and dip it in acid until it gives the desired deflection at only 150 lbs. per square inch. Worse yet, he will guess at the quantity of filling—which in the case of SO_2 for instance is an exact amount known to the maker—with the result that the scale will only be correct at one point (two at the most); or he will "evacuate" a vapor-pressure system by heating the bulb; or he will substitute alcohol for a nitrogen filling, etc.

Yes, much is involved in repairing such an apparently simple tube-system, and when you consider that the same holds true for flow meters, electrical instruments, and many classes of testing instruments, you will appreciate what a large investment is represented by a reputable repair shop or by an instrument company's "direct factory branch."

One large meter company does not solicit repair business, advocates that using plants maintain their own service, and gives several weeks' training in its own factory to men in the employ of its customers.

Finally, beware of "bootleg charts." A plant using thousands of dollars' worth of recorders on processes involving millions yearly naturally expects the utmost accuracy. To jeopardize it by taking a chance on cheaper charts made from photoengravings instead of wax plates . . . *that* is the falsest economy! Besides, part of the cost of an original chart covers the original research whereby the scale was established, so that it "isn't cricket" to buy pirated copies.

Automatic Weight Recording

By ERHARDT C. KOERPER*

CLOSER control of products and processes at increasingly higher speeds demands that the ancient and comparatively slow operation of weighing also become modernized to meet the exacting requirements of industry and commerce.

It is not the purpose of this article to go into the technique and mechanics of scales and automatic recorder design but merely to acquaint the production and practical man with their general operating characteristics, and to point out some common errors.

In the last two decades, refinements in precision instruments have been such that some laboratories are equipped to weigh smaller weights to a millionth of a gram. Obviously the working standards of production are in a different class: the nature and conditions of production work, and certain prejudices regarding the weighing problems of industry, have deprived them of the same intelligent attention which laboratory standards enjoy.

This has been especially true of the field of automatic weighing and the relatively new phase of automatic weight recording. Automatic weight recording is only such if all the operations are entirely automatic and each weight printed. A further development is the "adding machine" principle whereby the total for a day, or run, at each weighing point, is instantly available.

Origin

About 45 years ago, while H. A. Streeter, a Chicago steel manufacturer, was being detained by traffic blocking attributable to the slow manual method of weighing freight cars, it occurred to him that such delay was an economic loss to industry and he then set about to solve the problem of automatic weight recording. His vision and the mechanical ability of E. H. Amet, his associate, brought out the earliest satisfactory form of automatic weight recording. Streeter's solution of his self-imposed problem now saves huge amounts yearly in the world's freight yards and mines. Seeing that the same principle was applicable elsewhere, he and Amet built other automatic weight recording devices for industrial and commercial uses—the forerunners of modern Streeter-Amet Automatic Weight Recorders.

Design

Most automatic installations call for speed, accuracy and dependability. The design and operation of such equipment, therefore, should be analyzed from those viewpoints. Dependability is the important factor in securing speed and accuracy over a long equipment life. This in turn requires excellence in design and workmanship, and a satisfactory installation. The operating characteristics of most automatic or semi-automatic scales are more or less technical, and often the installation has to be made by specially trained men (though not necessarily highly technical).

Automatic weighing equipment may perhaps better be discussed by breaking it up into its parts which are:

1. The scales and lever system.
2. The recorder, which is composed of the balancing mechanism; the system transmitting the motion to the recorder; a visual indicator, if that be utilized; and a suitable damping mechanism which allows weighing while in motion.
3. Suitable mechanism which will print the weight at the proper time.

Details of scales and lever systems are generally well-known and nothing will be said in that regard other than that the recorder scale indicates what the scale and lever mechanisms direct.

From the above it is obvious that the scales should be of such construction and design that they will be adequate in size and properly installed. If such is not the case improper weights may appear in the recorder that are due entirely to the scale system. Because of this it is helpful to be able to check the accuracy and performance of the scales without the recorder being connected. This, of course, is an advantage that can only be provided for in the original design, and should be.

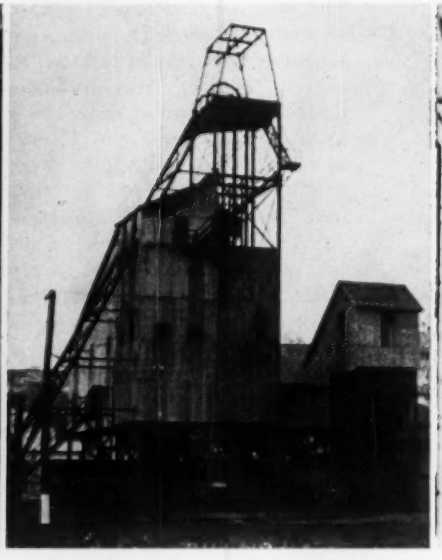
The vital part of the recorder mechanism is the device to balance the load on the scales. There are a number of moving poise systems both manually and mechanically operated. Use of the former with the printer mechanism is actually a manual system and subject to the same objections. The latter system in which a motor may be integral with a poise will obviously bring errors into being because of the changing weight of the poise due to the wear of the motor brushes and the gradual depletion and change of weight of oil in the caps, etc.

Where the motor is not integral with the poise and is connected by a series of worm and gears, the difficulty arises of backlash and lack of a suitable means of control. As yet this method has not been satisfactorily solved.

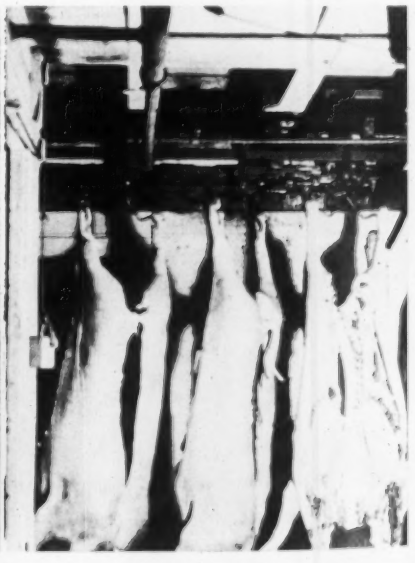
From experience and considerable research in both methods

*Chief Engineer, Streeter-Amet Company.

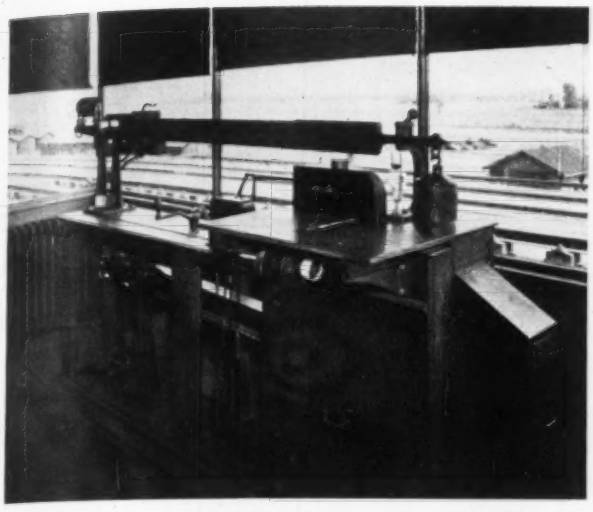
Intermittent charging of a glass muffle furnace. Ingredients are handled on over-head hoppers passing over a "live rail" connected to an automatic scale recorder giving the daily, monthly or yearly glass input. Inasmuch as these furnaces may run for several years without shutdown a positive check on input against production is important.



A unique West Pennsylvania power installation. At this point the coal is mined, cleaned, classified, automatically weighed and delivered to the power house less than 100 feet away. The value of positively checking boiler and unit efficiencies is obvious.



A hot hog line showing the track arrangement for automatic recording of the hogs while in motion. Routine weighing handles 1200 weights per hour over this recorder point.



Automatic weight recording in railroad classification yard. By this method automatic weights are taken in 10 secs.

a suitable weigh spring has proven to be the most satisfactory. Commercial accuracies are easily obtainable, as has been evidenced by years of proven performance. That properly designed springs are in the sphere of accuracy is daily proven by their use in various laboratory instruments the world over. Inasmuch as the tolerances of commercial weighing are of the order of 1/10 of 1%, the use of properly designed springs presents no objection from that source.

Pendulum systems are theoretically more accurate, but the additional number of moving parts in most pendulum scales detracts considerably from their accuracy and dependability. Heavy pendulum weights, moreover, are sluggish: in such systems it is extremely difficult to damp out undesirable vibration or oscillations. These two characteristics make pendulum scales inherently unsuitable for rapid weighing or for installations where vibration is present in an appreciable amount.

The objection to the varying modulus of elasticity for springs has been found in actual practice to present no difficulties. Within the temperature extremes found in customary working conditions no appreciable loss of accuracy has been noted. In locations where the equipment may be poorly housed and subjected to the extremes of hot and cold weather it is advantageous to maintain an even temperature in the spring housing.

Regardless of the system of weighing, a damping device is necessary if rapidly moving weights are to be taken. Such a system should have characteristics that allow a controlled variable speed of indicator or balance travel. A good illustration is the variable-speed travel obtained with the recuperator mechanism of guns. This action allows a rapid travel when the load is first applied and then rapidly decelerates the system till it reaches the correct weight point equilibrium. A good damping system will provide this without going by the point of balance. In addition, a good damping system will do much to prevent shatter and jarring on the pivot.

The two most popular systems of the translation of the weight into readable or printed figures are (1) lever systems, and (2) rack and pinions. Inasmuch as their design and operations present no unusual problem, they will be passed over without discussion. It is desirable, however, regardless of the system, that the motion be straight-line.

Track System

Weighing technique and practice have developed to such an extent that certain standards have been recognized by authorities in the field. This technique has only come about by experience and it should be consulted even where simple weighing systems are considered by the relatively uninformed.

There are untold numbers of cases where expensive weighing systems have been installed from specifications of a novice with the best of intentions. Good intentions will seldom replace experience. There is, of course, honest divergence of opinion among manufacturers in certain fields and phases. It is suggested that a number of manufacturers be consulted for preliminary suggestions. After the general specifications have been intelligently drafted it is a relatively easy matter to determine which system is best.

In cases where motion weights are desired, the equipment should be so arranged that the object to be weighed can be moved across the scale without acceleration or deceleration in any direction. Any change in the value of acceleration would be the cause of a corresponding change in apparent weight and result in an error. For this reason curved tracks should be eliminated, not only on the scale, but directly before or after leaving it. For gravity motion weighing the grade should remain constant across the scale and at least one weight length above and below the scale.

To obtain automatic operation it is necessary to provide a tripping mechanism that will actuate the printing mechanism at the proper time. In case of moving weights it is a relatively simple matter to connect a tripping bar on the scale track or guide rails. In cases where this weight is lifted or goes through a cycle of operation it may be more feasible to actuate the points through a cam. In any event it should be placed so as to give a maximum weighing time on the scale. For moving objects the trip is usually placed at the lower end of the scales so as to print just before the weight leaves the "live rails." Where a cam is used the tripping stud should be located on the cam surface so as to print just before the load is lowered and the scale relieved of the weight.

The Human Factor

The human factor is always a potential source of error. To expect an individual to pursue his work continuously without a slip is not within reason. In some cases where the operations are controlling large volumes of relatively high unit values, or where the material handled represents a large proportion of the sales price, close control is vital. In these cases an accumulation of errors, and sometimes even a single error, may equal the cost of an entire installation which could obviate the possibility of such an error. The human factor might be discussed at length under each of the following heads:

1. Errors due to improper or inaccurate setting.
2. Errors due to incorrect reading of the weights.
3. Errors made in writing or transcribing the weights to the permanent record.
4. As in the reading of all instruments there is always a personal error. This is perhaps most apparent when articles are reweighed for checking by another individual. Everyone has his own technique, no two of which are exactly the same.
5. Though not an error, it is a great disadvantage not to be able to check the weight without reweighing the article.

An automatic printed weight eliminates all these possible errors and disadvantages inherent to manual weighing.

In addition, printed weights have been of considerable aid in the settling of controversial weights and for purposes of checking. Such records have also proven to have considerable value as legal evidence in court. Cases are on record in which expensive law suits have been won entirely by such evidence. By the same token, lawsuits have been avoided.

Most organizations have a strategic point at which production or the flow of materials in process of fabrication may be or is being held up. As in the case of weighing operations, to eliminate a weakness at this point increases production and allows an even flow. By effecting this, greater production and larger plant capacity is achieved without actually increasing the size of the physical production units or adding personnel.

Applications

Some of the more common applications are found in the railroad and freight yards. Mines weigh coal, ore and their by-products at the different points of processing or working. Glass plants, steel mills and batching operations make profitable use of automatic weight recording. The production lines of plate and tube mills have such "cash registers" of industry at strategic points to record the weight of hot ingots, bars, hot plates, tubes, steel plates and scrap material. Automatic recording *absolutely checks* the disposition of all material.

Meat packers are enthusiastic about having a rapidly printed automatic weight for each outgoing piece of meat. This has been perfected so that the accumulation of the weights of a particular run or day may instantly be had. The enormous saving in time and costly errors are obvious. A medium size New York packer passes daily on an average of 2000 weights over a recorder on his "hot hog line." A large Chicago packer handled as many as 1200 weights *per hour* over one recorder.

The advantages of an automatically printed weight while in motion are great. The outstanding factors are, with the proper equipment, the speed and accuracy with which weight can be taken without the error involved in the human element.

Automatic weight recording has come as a boon to production and the advantages that the system brings with it well warrant consideration in plants of all sizes. Scales and their indicators are just as surely "cash registers" of raw material as the clock and cash drawer are of time and money.

The ENGINE INDICATOR

Its Design and Theory

(Continued from October Issue)

By KALMAN J. DeJUHASZ*

INDICATING HIGH SPEED ENGINES

Owing to the inertia of its moving parts the pencil of the indicator does not describe the true pressure line but superimposes upon it its own natural vibrations. Due to this an error results, the magnitude of which is the greater the more rapid is the pressure change and the longer the natural period of the moving parts.[3]

On a slow speed steam engine (with a low rate of pressure change) the superimposed vibrations may be as small as to be hardly detectable. On a high speed engine, or on one with a high rate of pressure change, the vibrations may entirely distort the diagram and render it useless for evaluation.

In order to reduce the error, it is necessary that the natural vibration period of the pressure measuring parts should be small in comparison with the time of a given change in pressure. As the rate of pressure change in engines of the same type is roughly proportional to the engine speed, the above stated requirement can be formulated in other words: that the number of indicator vibrations per engine stroke should exceed a certain permissible minimum. This "permissible minimum" is an arbitrary quantity, for which let us assume 10. With this value for an engine of 100 r.p.m. the natural vibration period of the indicator should be less than $\frac{60}{2 \times 100 \times 10}$ $\frac{1}{33}$ sec. while for a 1000 r.p.m. engine $\frac{1}{333}$ sec.

Similar considerations prevail for the drum. Its natural frequency must likewise be high if whipping of the cord, and consequent distortion of the volume scale, is to be avoided.

With the ever continuing augmentation of speed which characterizes the trend of development of our piston engines grew the necessity of building indicators for their investigation. The way lies, as shown above, in reducing the periodic time of the indicator vibration in an inverse ratio to the speeds employed.

The natural period of vibration, T_o of a moving mass m with c elasticity (= force per unit displacement), can be expressed as:

$$T_o = 2\pi\sqrt{\frac{m}{c}}$$

Taking the case of an actual good indicator for steam or Diesel engines as an example in which

Weight of moving parts reduced to the cylinder axis = 78 grams;

Spring Scale = 180 lbs./in.^{2}/in. acting on a 0.5 in.^{2} piston area;

Magnification 6 times

the following values are obtained:

$$c = \frac{180 \text{ lbs.}}{\text{in.}^2 \times \text{in.}} \times 0.5 \text{ in.}^2 \times 6 = 540 \text{ lbs./in.}$$

$$= 96000 \text{ g. cm.}^{-1}$$

$$m = \frac{78 \text{ g}}{981 \text{ cm. sec}^{-2}}$$ the periodic time will be

$$T_o = 2\pi\sqrt{\frac{78}{981} \cdot \frac{\text{sec.}^2}{96000}} = \frac{1}{175} \text{ sec.}$$

According to the above assumption, the maximum speed at which this indicator would supply usable cards is: $\frac{60}{2n} = \frac{1}{17.5}$ whence

n (=) 530 r.p.m.

The natural period of vibration can be reduced by raising the c (by using a stiffer spring), or, by lowering m (i.e. by making the moving parts lighter), or by both. The difficulty is however, that the fraction m/c must be reduced $1/n^2$ times in order to reduce the periodic time to $1/n$th of its original value. Furthermore, it must be noted that increasing c means reducing the ordinates of the card, which renders the evaluation more difficult. Hence, the difficulty of adapting the indicator for high speed work increases rapidly with the increase of engine speed.

The speed limit at which a given indicator of normal type is usable can be attained by using the piston and

---

[3]See K. J. De Juhasz: Versuche an einem Automobilmotor. Auto-Technik. Forschungsheft No. 2. 1923.

L. Pendred. High Speed Engine Indicators. Engineering. Jan. 26, 1923, 2 p.

W. Wilke. Untersuchungen ueber die Grenzen der Verwendbarkeit des Indikators bei schnellaufenden Maschinen fuer elastische Medien. (Investigations on the limits of usability of indicators on high speed engines working with elastic media.) Der Oelmotor, 1916. No. 5/6.

*Asst. Professor of Engineering Research, Pennsylvania State College.

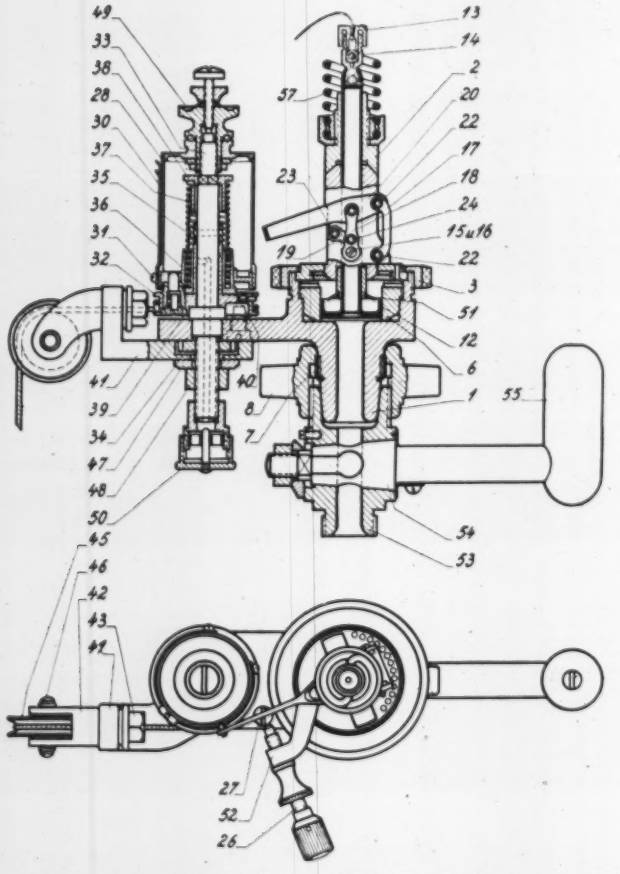


Fig. 69. High speed engine indicator (Maihak). Note the unusual arrangement of the recording gear and its platform, shortness of piston rod and spring.

spring combination giving the least height for the card and by using as short a drum amplitude as practicable.

It is more effective to construct a small indicator altogether, i.e. one with small piston travel and drum displacement, giving the smallest card compatible with convenient evaluation. Such indicators are shown in Fig. 15 and 69. Another refinement is the use of a large piston and of a very stiff spring, whereby the weight of the recording gear per unit of piston area is reduced.

Fig. 70 shows the Geiger Indicator (Lehmann & Michels) built on this principle. The Maihak indicator[4] (Fig. 71) uses a cantilever beam spring which makes possible a very compact construction. The magnification is 8 times. According to the makers, its natural period of vibration with a 180 lbs./in.² in. spring is 1/400 sec.; with a 36 lbs./in.² in. spring, 1/175 sec. According to the above-mentioned arbitrary ruling of 10 permissible vibrations per engine stroke, this indicator would give usable cards at 1500 r.p.m. with the stiff spring and at 500 r.p.m. with the weak spring.

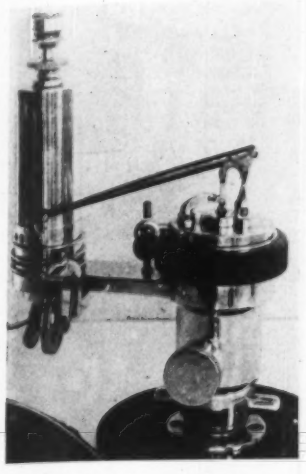


Fig. 70. Geiger's Indicator (Lehmann & Michels) embodying large piston, internal spring and large magnification.

Another type of indicator, made by Lehmann & Michels, Fig. 72, employs an outside helical spring with a 7 times magnification ratio. A hollow recording lever

[4] v. Gehlen. Neuer Maihak Indicator. V.D.I. 2, Aug. 1924. 2 cols. 3 figs.

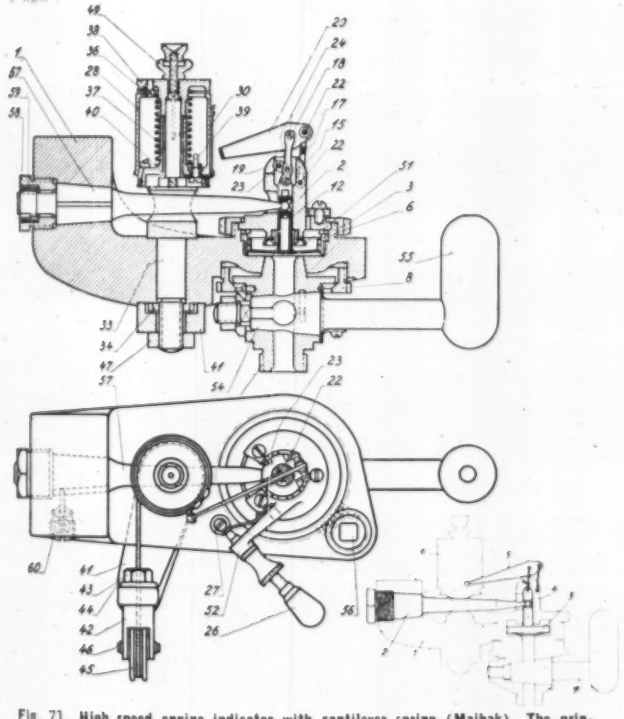


Fig. 71. High speed engine indicator with cantilever spring (Maihak). The principle (Fig. 71a) involves the use of large piston 3, cantilever spring 2 which fits with its ball shaped end into piston rod 4, recording gear with 8-times magnification. Piston rod can be made very short. Note compact construction; cantilever spring passing through the drum post. Indicator cock is connected to body by means of cone and retaining nut 8 which is provided with teeth around its periphery and can be tightened by means of wrench 56.

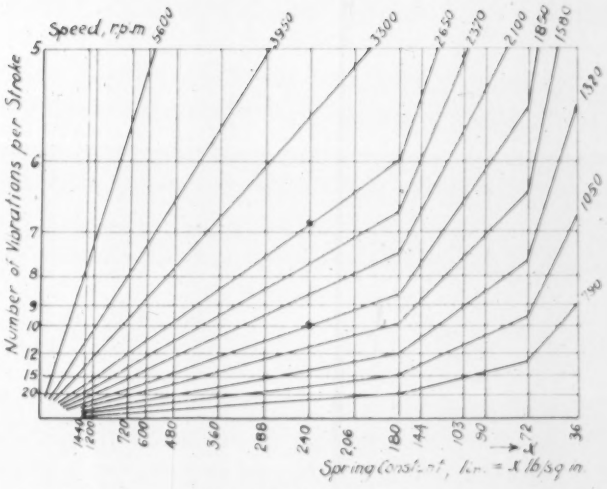


Fig. 71b. Spring chart of Maihak Cantilever High Speed Indicator giving the number of vibrations per engine stroke with different springs and for different engine speeds. For example a spring giving 1 in. displacement of the pencil point for 240 lbs./in.² pressure will give about 7 vibrations per engine stroke when used at 2650 r.p.m. and 10 vibrations per engine stroke when used at 1850 r.p.m. Such a chart is very helpful in choosing the suitable spring for a given engine speed and its general adoption would be advantageous.

of uniform strength form is used. These instruments represent the utmost refinement attained at the present time in the direction of adapting the normal pencil type indicator to high speeds. At the same time the diagram size (about $\frac{5}{8}$" high by $1\frac{3}{4}$" long) probably represents the limit of size which is still compatible with the practicability of evaluation.

A still further decrease of the vibration period can be attained only by the use of springs so stiff, i.e. with displacements so minute that it is necessary to provide a powerful magnification of the resulting diagrams by other than mechanical means. Thereby the simplicity and ruggedness of construction and the convenience of operation inherent in the mechanical type of indicator are sacrificed. Furthermore, the diagrams obtained must be used with caution and are usually suitable for qualitative interpretation only, but not for accurate quantitative evaluation. According to the magnification means adopted, these instruments fall into 3 groups, i.e.: micro,

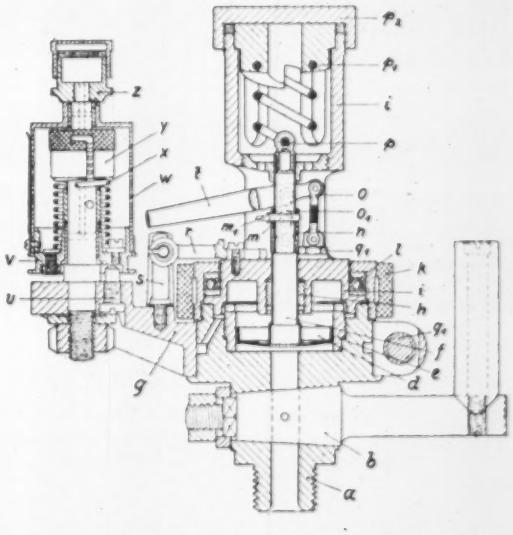


Fig. 72. High Speed Engine Indicator (Lehmann and Michels). It incorporates an external helical spring in compression which makes possible the use of a short piston rod. Magnification 7 times. Note method of attachment of recording gear to piston rod by means of sleeve and pin. Drum post can be rotated around indicator body and clamped in any position by means of clamping screw g_1. Fig. 72a shows the external view of the instrument; Fig. 72b shows the reduction gearing for the drum drive incorporating a variable r/L ratio and phase changer device for taking offset cards.

optical, and electrical indicators. All these apparatus require considerable expertness for their operation and can be used only under laboratory conditions by trained investigators.

MICRO-INDICATORS

With the aid of micro-indicators a diagram of microscopic size is obtained which is subsequently observed visually by means of a microscope, or magnified and photographed by suitable apparatus. This method was originated by O. Mader in 1912. In his indicator, shown

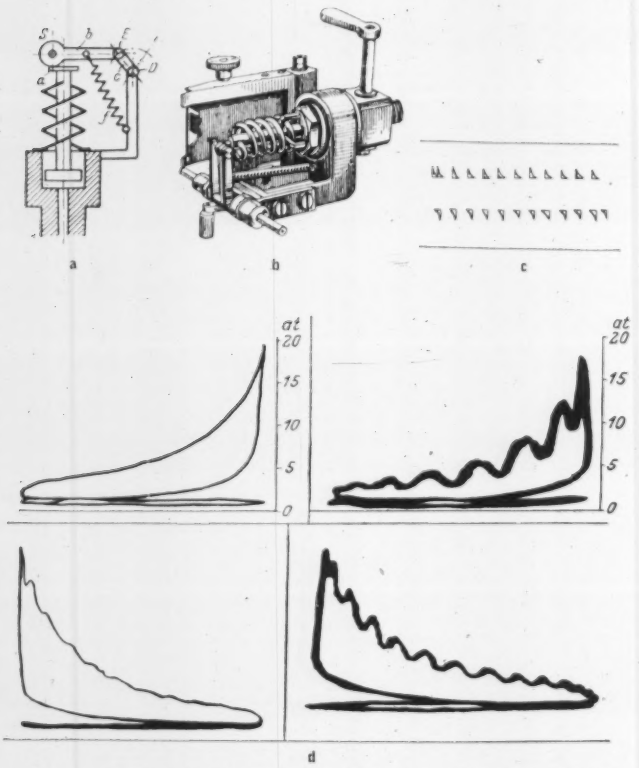


Fig. 73a shows the principle and 73b the actual form of Mader's Micro Indicator. (Gebr. Staerzl, Muenchen, Germany) A short piston rod carries a platform a upon which slides the circular end of the writing lever b, which is kept in contact with the platform by means of spring f. The writing lever is oscillated bodily, in unison with the engine piston, by means of rocking lever c. The stylus S therefore describes a compound motion incorporating both the motion of the indicator piston and also that of the engine piston. The stylus scratches the resulting diagram upon a stationary, smoked glass tablet, in its original size, without magnification. By sliding the tablet, 24 diagrams can be drawn upon it in quick succession. The size of the diagram is about 2x2 mm. Such a tablet is shown on Fig. 73c while 73d shows the diagrams magnified photographically.

in Fig. 73, the recording stylus executes both the pressure-recording and the volume-recording, motion, while the card, in this case a smoked glass, remains stationary. By shifting the glass plate in its guide, 24 diagrams can be drawn in succession, which are about $0.15'' \times 0.10''$ in size. Immersing the smoked glass in Canada balsam makes the cards permanent.

Another representative of this group is the micro-indicator of Collins,[5] shown in Fig. 74 which was introduced in 1922. This instrument has the following characteristic features: for loading the piston a cantilever spring; for the recording of the diagram a celluloid disk which is rocked in unison with the engine piston displacement, and which can be turned around its central pivot and receive 10 diagrams; electromagnetically operated recording stylus whereby the contact of the stylus with the celluloid disk is limited to one single engine cycle. An advantage of this instrument is the remote control. The lower limit of size to which a micro diagram can be reduced without sacrificing clarity depends to a large extent upon the width of the diagram line. This in turn depends on the material of the stylus and the plate, and the contact pressure between them. In the micro-indicator of the Deutsche Versuchsanstalt fuer Luftfahrt developed by W. Pabst[6] a diamond stylus scribes upon a hard glass plate. (See Fig. 75.) With a stylus cone of 60° and a contact force of 5 grams a line width of only 0.002 mm. (0.00008 in.) has been attained. In virtue of this extreme fineness of the line the diagram

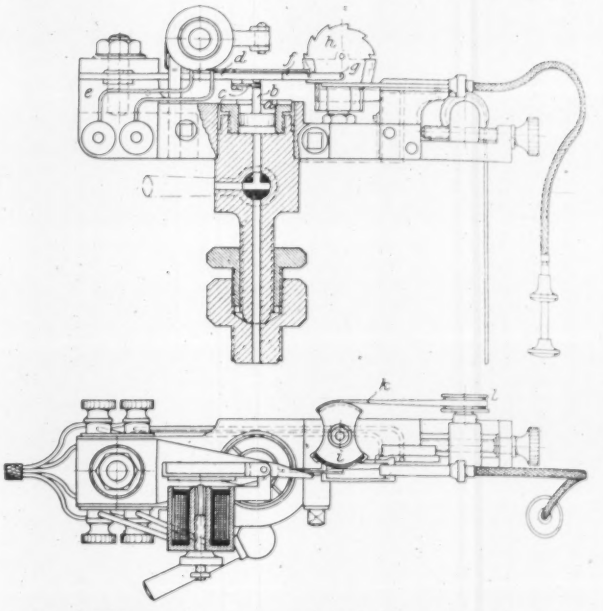
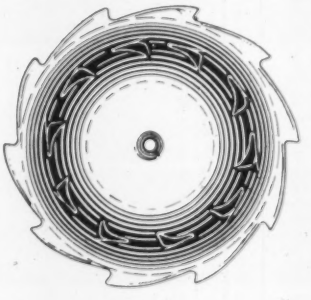


Fig. 74a (above): Collins' Microindicator (Cambridge Instrument Company). A cantilever spring d (flat plate, triangular shape for uniform strength) is used to which the writing lever f is pivoted. The stylus can be brought into connection with the celluloid film h by means of an electromagnet. The film is fastened to the cylindrical drum i which is rocked, by means of a steel ribbon k, in unison with the engine cylinder. The film is of ratchet disk shape and can be moved tooth by tooth with the aid of a Bowden wire mechanism. In this manner 10 diagrams can be taken on one disk. A card is shown on Fig. 74b (at side). The individual diagrams are 0.1 in. high by 0.125 in. long. An electrical arrangement is provided to ensure that the stylus is pressed on only during one engine revolution.



size can be very small, hence a stiff indicator diaphragm can be used. It is stated that the natural frequency of the diaphragm alone is 1600 per sec. while that of the complete recording assembly (diaphragm, plus recording mechanism) is about 1200 per sec.

The pressure indicator built upon this principle is shown in Fig. 75c in its external appearance and in Fig. 75d without the hood protecting the internal mechanism. In use the instrument is screwed into a spark plug hole. The pressure line is inscribed with a diamond point upon a glass plate moved by clockwork. The dead centers are marked on the glass plate in another line, drawn by a second diamond point, actuated by an electromagnet, which is in turn energized by means of a contact ring driven by the crankshaft or by the camshaft of the engine. This determines the phase relationship of the pressures and makes possible a re-drawing of the diagram on a volume basis for the purpose of determining the mean indicated pressure.

[5]W. G. Collins. Micro-Indicator for High Speed Engines. Engineering. Jan. 26, 1923. 5 cols. 5 figs.

[6]W. Pabst. Aufzeichnung schneller Schwingungen nach dem Ritzverfahren. V.D.I. 16. Nov. 1929. 10 cols. 14 figs.

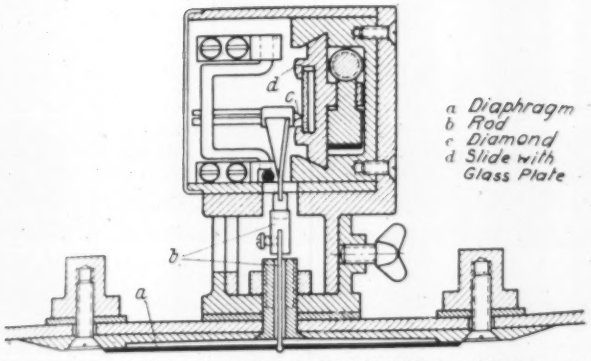


Fig. 75a. Micro-indicator of the Deutsche Versuchsanstalt fuer Luftfahrt, using diamond stylus and glass plate. The apparatus actually shown is intended for measuring the water pressure acting upon a seaplane float, but the general principle is applicable also for engine indicating purposes.

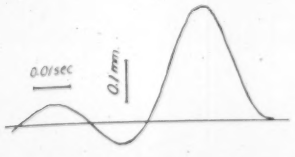


Fig. 75b. Diagram of pressure shock recorded by the apparatus.

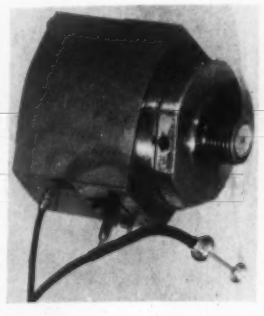


Fig. 75c. External view of the DVL microindicator.

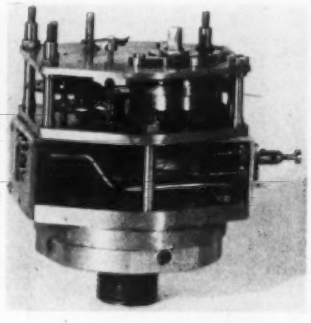


Fig. 75d. DVL microindicator, with protecting hood removed.

The clockwork can be put into, and out of, action by means of a Bowden cable trigger, like a camera shutter. The speed of the clockwork is kept constant by a small windmill, driven at a very high gear ratio from the clockwork. There are windmills of various sizes, interchangeable with one another, whereby the speed of the glass plate can be changed at will.

Drawing the pressures on a time basis obviates the necessity of a drive from the engine shaft which is inconvenient to arrange in most cases and is always a potential source of error.

(Continued on Page A11)

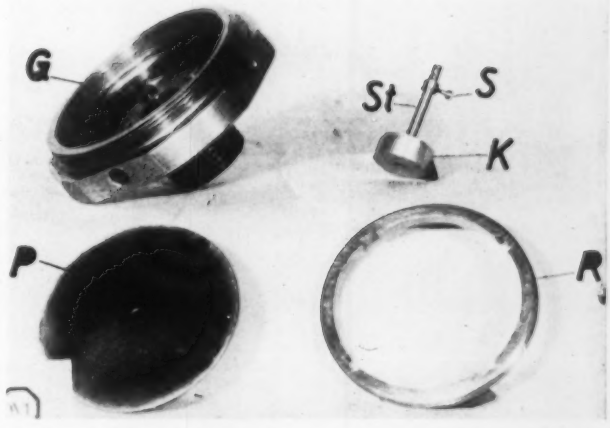


Fig. 75f. DVL pressure unit dismounted. G—housing; K—indicator piston; St—piston rod; P—diaphragm; R—clamping ring; S—clamping screw for the diamond point.

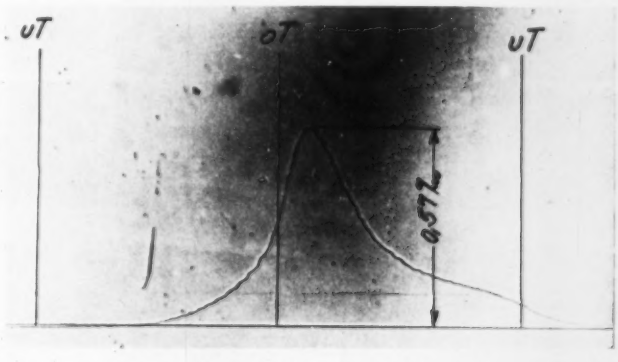


Fig. 75g. DVL diagram magnified.

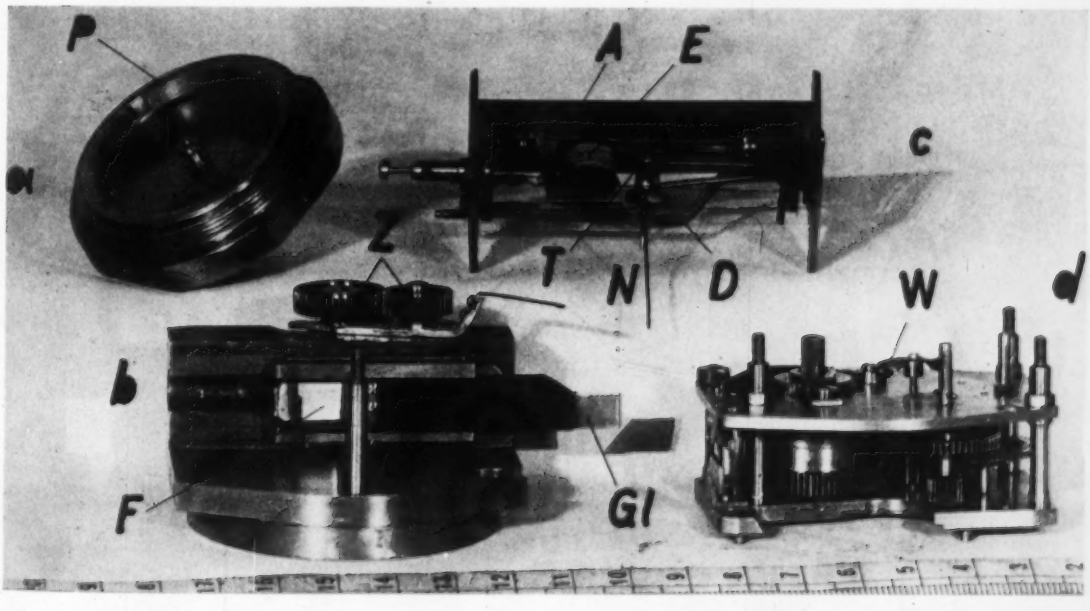


Fig. 75e. DVL microindicator dismounted into its various parts. a—pressure unit; b—glass movement; c—writing gear (viewed from the direction of the glass plate); d—clockwork; P—diaphragm; D—diamond point for pressure; N—rod for diamond point; T—diamond point for marking the dead center; E and A—electromagnet and its shoe; G—glass plate for recording; F—slide for glass plate; Z—tooth wheels for driving the slide; W—windmill. (The scale—centimeters—is placed there for comparison.)

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Flow Measurement and Control*

By M. F. BEHAR†

CHAPTER XXIII
POSITIVE METERS

(Continued)

1. The Industrial Distinction Between "Positive" and "Positive Displacement" Meters

As the A.S.M.E. Fluid Meter Committee properly points out in the opening paragraph of Chapter 1 of its Report, the term "positive," among others, has "been used ambiguously or inconsistently." In the next paragraph the committee, representing not only the engineering profession but industries and the Bureau of Standards, lays down a definition of positive meters which specifies that "no fluid can pass through such a meter without actuating the primary device."

Now, in formulating the elements of Instrumentation, one does well to follow some recognized authority when treating any particular field of measurement. In the field of fluid metering now being dealt with, the A.S.M.E.'s maturely considered terminology and principles of classification, which stand out as logical, consistent and unambiguous, are the ones which we have chosen to follow.

It so happens however that this very lack of ambiguity—in the *first* chapter of the Report, where the groups, divisions and classes are defined—has created a rather paradoxical situation among engineers concerned with specifying, using or manufacturing quantity meters, because of the practical impossibility of making truly "positive" commercial meters of certain types that are in demand by reason of their convenience, simplicity and low cost. The practical point of view striven for throughout this Manual demands that in *this* chapter we take account of a state of things prevailing in the oil and other meter-using industries. In these industries "monkey-wrench and screwdriver mechanics" are either giving way to engineers or studying to be engineers themselves, while the vague classification and loose terminology of former days are giving way to engineering specifications. Not so long ago, the men who specified positive meters did not belong to engineering societies, did not know that a representative committee had laid down a scientific set of unambiguous definitions in 1922; today they not only know it but some of them have discovered that the Report, like certain laws, "has teeth in it" and they sometimes demand the impossible. The greater the proportion of industrial engineers thus "armed" with the Report, the more the situation grows serious. Scrupulous sales engineers, who honestly admit that some of their meters are not truly "positive," suffer under a handicap.

Strictly interpreted, the Committee's definition implies that no matter how low the rate of flow through the meter, every drop of liquid or every cubic inch of gas must actuate the primary device. While some commercially produced weighing meters can meet this requirement, most of the devices in the great field of commercial, industrial and public service volumetric metering, which by usage and custom are called *positive displacement* meters, would be excluded if the letter alone of the definition were adhered to. It obviously is impracticable to manufacture and sell against competition a meter of the rotary type (for example) which will register at all when, after a period of inoperation, less than a tenth of 1% of its rated capacity is to be metered. The plain fact is that only such types as the valveless wet drum (for gases) and the tilting tank (for liquids) employ truly positive principles whereby, not only when the meter is new but after working parts have begun to wear, every cubic inch is registered and every drop caught. And even a meter in which buckets are filled and emptied is not absolutely positive, because open vessels permit evaporation, so that in the case of a volatile liquid the totalized

*Part Six of *The Manual of Instrumentation.*
†Engineering Editor.

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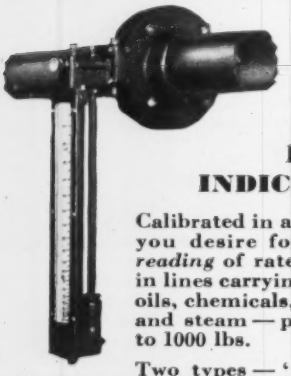

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quantity at low rates of flow is less than that delivered to the meter and more than that delivered from it. Moreover, spouts and valves are seldom positive in their action.

The specific cause of this situation, which will remedy itself in time, is that while Part I of the A.S.M.E. Report, containing its excellent classification, has been out for a decade, its descriptions of those meters which it calls positive have not been released. Meanwhile, the very uncertainty which the Committee aims to dispel seems to grow apace as waterworks, oil, and gas engineers, in ever-increasing numbers, adopt the Report and observe that right alongside of the definition of "positive" there appears the following classification of positive volumetric meters:

Type	1.1 Tank	Type	1.4 Rotary
	1.2 Piston		1.5 Bellows
	1.3 Disk		1.6 Wet Drum

At least four of these six types listed by the Committee as positive are not produced commercially in truly positive models. In all commercial models there is considerable slippage at extremes of flow rate.

Searching the Report for ifs and buts, the prospective user of such meters finds none. On the contrary, he finds that Chapter 3, on volumeters, taking up less than a quarter-page, states tersely and unequivocally that "errors due to time element in operation of valves, trips, or siphons, are corrected empirically by test." No mention of relation of slippage to rate of flow. Moreover, he finds in Chapter 1 under the definitions of inferential meters, that current meters are "radically distinct from the positive meters in that they do not pass the fluid through in separately isolated portions . . . Fluid may pass through with little obstruction, even though the mechanism be blocked." From which he may infer that a positive meter must also be one which, if its mechanism is blocked, will not allow any fluid to pass through. This rigid interpretation has the weight of engineering authority, as some readers know by experience. This authority rests largely on that of the Committee which, though working under A.S.M.E. auspices, is widely representative, so that when (not if) the remaining parts of Report are published with descriptions of commercially available piston, disk and rotary meters under a heading that includes the word "positive," those who are inclined to lay down impossible stipulations for the performance of meters will be shorn of a weapon they now wield—a document intended to promote harmony, not controversy.

In the waterworks, oil and gas industries, the designation *Positive Displacement* has for years been applied to meters of types falling within the Committee's positive volumetric class. Today it is used extensively—if not universally in these fields, where it carries an exact meaning, namely, displacement of some mechanical part. For example, a reciprocating piston meter so designed that the stroke of each of its pistons is exactly limited by micrometer stops is considered a positive displacement meter, even though it does not register an extremely small flow, and allows some fluid to pass when its mechanism is blocked. "Fixed displacement" and "controlled displacement" are also used in the service industries to denote meters of volumetric types.

Recognition of both the "leakage" and the "slip" or "slippage" of commercially produced positive meters in the first chapter of the next revision of Part I of the Report would seem to be called for; and use therein of the term "displacement" would be most welcome. In addition, the inclusion in Part III (now in preparation) of notes on the distinctive characteristics of truly positive and positive displacement meters will end the anomaly once for all.

2. General Characteristics of Positive Meters

(a) Readings and Records Obtainable

Most positive meters are quantity meters. Their distinctive characteristic is that they *register* the total flow passed. This registration usually consists of the usual incremental indication readable on a counter, "index," "dial" or "register" but it may be recorded on a chart, a light or short mark being made every ten cycles, for example, and a heavy or long mark every fifty cycles—or a "wave" form of record being produced. When such a chart is clock-driven, the record gives the mean rate of flow between marks or crests, just as the mean load of a domestic meter can be computed from the increment when the time since the last reading is known, but with the advantage over the computing method that variations in rate, during the chart period, show up at a glance.

Rate-of-flow indications and records cannot be obtained from a "plain" positive meter, which by definition consists of a quantity-measuring primary and of a counting secondary. In this sense, if we draw the analogy to the field of speed measurement, positive fluid meters correspond to revolution counters while inferential fluid meters correspond to inferential tachometers such as those of the centrifugal and electromagnetic classes.

But this is all a matter of definition, arising from the historic (and even today practically universal) use of positive meters as quantity meters, that is to say quantity counters. There has lately arisen a demand for fluid meters with primary devices of positive types and secondary devices giving direct

reading of rate of flow. Such meters correspond to the positive direct-reading tachometers*—that is to say the integrating chronometric, the conjugating chronometric, and the geometric (these last in principle only, because the usual fly-ball tachometer is an inferential instrument). Such fluid meters consist essentially of a positive primary device, measuring off isolated quantities, and of a tachometric secondary.

Now what—as the foreman told the idler who said he had to make a living—is the necessity? Why not use an inferential primary device in the first place and get a rate reading directly? Why not use a head meter which is a quantity-rate meter and which, in metering a gas at fluctuating pressures, gives a more correct indication of the B.t.u. supply rate than does an uncorrected volumetric positive meter?

Because there are required at some stages of some processes—mostly in the chemical industries—dependable indications and/or records of the instantaneous values of the true *volumetric* rate. (A similar need no doubt exists here and there for gravimetric rate indications, obtained from a weighing primary and a tachometric secondary, but at this writing we lack details showing why other instruments would not do.) One example is so striking as to deserve mention: A well-known apparatus sold to numerous plants, comprising a fractionating tower and related equipment, includes a positive fluid rate meter in the form of a thermodynamic engine and a tachometer. The engine is a reciprocating type in which the gaseous fluid expands and performs work, so that the inlet and outlet (or supply and exhaust) temperatures, pressures and viscosities differ considerably. Various well-known types of meters, installed on the line to or from this engine, would give readings definitely related to the engine speed, but any change in the condition of the fluid would alter these relations, making each meter show an "error" with regard to the two others, and the whole point is that the tachometer reading is a perfect operating guide for controlling the process, while *either* of the two other possible readings would be insufficient and *both* would require corrections—not because they are inferential but because they do not represent the particular object of measurement to which the volumetric "engine type" piston meter automatically assigns instantaneous values.

(b) Suitability for Automatic Rate Control

Before a condition can be controlled, it must be measured. A requisite of any system for controlling flow rate is a rate-of-flow measuring element. Being fundamentally quantity meters, positive meters as such cannot furnish the required continuous measurement of instantaneous flow rate. However, the combination of a continuous positive meter and of a time element does provide a rate indication. In some cases this kind of rate indication (generally of

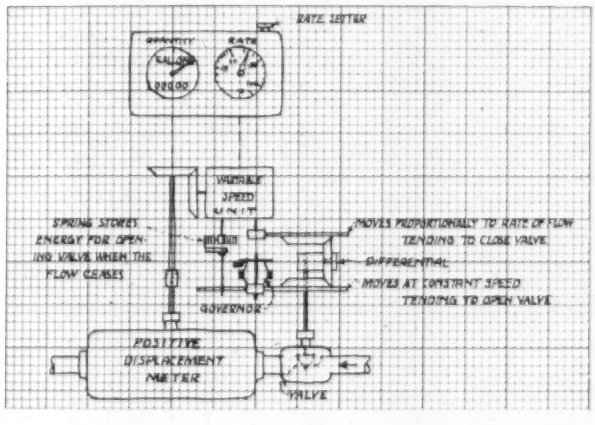


Fig. 23-1

volume-rate) is more suitable than that furnished by an inferential meter affected by fluctuations of density, viscosity or pressure. Fig. 23-1 is a rough sketch of a flow control system developed in late 1932 in order to "measure out" a definite volume-*rate* with the utmost precision. That such control systems in general possess decided advantages will be brought out in Chap. XXVIII, but the fact that this one was developed by Builders Iron Foundry (originators of the standard Venturi and of automatic flow controllers employing Venturi primary elements) is significant. One noteworthy advantage is that if the auxiliary power should fail, the system becomes self-operating. This is a characteristic of this particular system, but a distinctive possibility with positive metering automatic rate control systems in general is that the system's primary element may itself be used as the final element—when it is so sturdily built that it can withstand this service, and of course when the

*For a discussion of the principles involved see Part Five, Ch. XXI, §2, Art. b. In connection with the above text it affords a vindication of the doctrine that all branches of Instrumentation are interdependent: Following closely the A.S.M.E.'s rational method of classifying all fluid meters, the author had worked out an exactly similar method applying to all speed measuring instruments. In the course of this research it turned out that certain types of instruments for the positive measurement of speed (positive count of revolutions in positively fixed time intervals) represented corresponding types of fluid meters that did not fit into any of the mutually-exclusive categories defined by the Fluid Meter Committee.

INSTRUMENTS BOOK SHELF

The books reviewed in this section can be supplied by the Instruments Publishing Company.

Meteorology. Donald S. Piston. P. Blackiston & Son Co., Philadelphia, 1932. 187 pages. Cloth, 9 x 6 inches. Price $2.50.

"The book has been written primarily as an elementary text on meteorology for college courses . . ." The book gives a concise and clear exposition of the fundamentals of meteorology. The treatment is wholly qualitative, since the author does not assume a knowledge of the calculus by the reader. Yet he manages to introduce with unusual clearness the fundamental notions of the deflecting force of the earth's rotation and of the balance of forces in cyclonic and anticyclonic circulations.

Some deficiencies exist in the book, as follows: The treatment of the thermodynamics of the atmosphere appears to be somewhat incomplete. While a derivation of the adiabatic lapse rate is difficult without the use of the calculus, the expression of this fundamental meteorological quantity in terms of physical constants should have been brought to the attention of the reader. No mention is made of the formation of subsidence inversions and of the fact that under normal conditions of stable lapse rates turbulence carries heat downwards. With regard to the subject matter on page 28 it would seem that a plausible explanation, due to Humphreys, of the clouds which appear at sunset and disappear shortly afterwards is that they are formed through cooling by radiation and are dissolved by subsequent sinking and adiabatic heating. We find in Chapter III statements which need qualification. Thus, on page 36: "if the atmosphere is saturated no evaporation takes place" is true only if the temperature of the evaporating water surface is not greater than the temperature of the air. The definition of dew point, on top of page 40, as "the point at which moisture begins to condense on cooling" does not bring out the dependence of the dew point on the specific volume or on the total pressure of the air.

The discussion of the rather involved subject of the meteorological aspects of radiation is very brief and contains a few errors. On top of page 71 water is classed with snow and ice as one of the poorest absorbers of solar radiation whereas actually it is found to be a poorer reflector than bare ground. The statement at the bottom of the same page that "those surfaces that are poor absorbers of radiation, such as snow and ice, show less of a drop in temperature by nocturnal radiation" is incorrect. It is true that snow and ice are poor absorbers of solar radiation, but they are perfect radiators for terrestrial radiation. No mention is made of the role of water vapor in the absorption and scattering of solar radiation. The reference in 73 to the work of Humphreys is mistaken, since it appeared already in the Astr. Journal 29, 14, 1909, simultaneously with Gold's treatment of the same subject in Proc. Royal Soc., 82, 43, 1909.

It is to be noted that the author does not introduce the concepts of virtual temperature and of geopotential and that he does not label the turning of the wind with altitude by the generally accepted name of the Ekman Spiral.

The second half of the book which deals with synoptic meteorology is up to date and is admirably done. I should therefore not hesitate to recommend this book as an introductory textbook in synoptic meteorology.

—C. L. Pekeris (10) ■

Scales and Weighing Arrangements. (Waagen und Wiegeeinrichtungen.) Ernst Götz. Dr. Max Jänecke, Verlagsbuchhandlung, Leipzig 1931. Paper, 8¼x6 inches, 210 pages, 9.60 RM.

The author, a professor at the Vereinigten Staatlichen Maschinenbauschulen in Würzburg, describes the type of scales now being built in Germany. Since automatically indicating scales with pendulum counterbalancing mechanism were prohibited in Germany until around 1922, it is interesting to note the number of different constructions designed and placed on the market since their approval.

Several chapters are devoted to historical data, illustrations and construction details of the earlier lever and even balance types. If it was the author's intention to cover the entire field of scale construction, as these chapters seem to imply, he falls short of the mark. A large portion of the subject matter of these chapters was more thoroughly discussed by Dr. E. Brauer in *Die Konstrucktion der Waage*, later translated into English by H. C. Walters on behalf of the Incorporated Society of Inspectors of Weights and Measures (Great Britain).

Considerable space is devoted to platform releasing or locking means, a detail of scale construction not essential to the design of scales for use in this country, since such means are neither required nor desired.

Owing to some of the peculiar requirements of the German weights and measures laws, a type called "Schaltgewicht" scales (Unit Weight Scales) were developed; these are discussed at length.

Since pendulum scales are mainly of American origin and development and as some of the German types at best, are mere copies, the lack of a chapter discussing the originals is felt.

The book, however, is interesting, if for no other reason than that it is an addition to the meager bibliography of scales and weighing.—Carl Zinke.

(2.03) **B**

Mechanical Movements. (Les Mouvements Mécaniques.) Marcel Nicaise. Ch. Béranger, Paris, 1931. Cloth, 6x9½ inches, 694 pages. Price 208 francs.

This is a comprehensive work dealing with the vast field of mechanical motions in a systematic manner. The various motions are classified according to their governing principles. After defining the fundamental mechanisms the author discusses their combinations and describes in detail their more important applications.

In a short review it is hardly possible to treat fully the very extensive subject matter of this large work but the following list of chapters will give an idea of its scope and contents: General Concepts. Fundamental elements of mechanisms (linkages). Transformation of the fundamental elements. Mechanisms formed by a single fundamental couple. Principal kinematic chains of lower order. Trajectories of chains of lower order. Analysis of velocities. Analysis of accelerations. Analysis of linear trajectories. Analysis of surface trajectories. Analysis of volume trajectories. Higher chains with continuous sliding contact. Higher chains with discontinuous sliding contact. Chains with rolling surface (cylindrical, conical and spatial). Toothed gears (cylindrical, conical, hyperbolical, helical, spiral). Trains and combinations of toothed gears (with fixed axes, epicyclic and their combinations). Non rigid members (flexible, torsible, compressible, extensible). Elastic members (springs, diaphragms). Elements with variable volumes (rotary pumps and kindred mechanisms).

The various mechanisms are copiously illustrated with schematic drawings and their kinematic properties are analyzed by both graphical and mathematical methods. The author does not presuppose a very high degree of mathematical knowledge on the part of the reader. The order of sequence is logical, the subject is built up from simple examples to complex combinations. The style is clear and easily understood. In the opinion of the reviewer it is a good textbook, even for self-study, for those who are sufficiently conversant with the French language.—K.J.DeJuhasz

permissible pressure drop is large enough. A simple form of such a system comprises only a water meter equipped with an ordinary friction governor of the phonograph type. The water meter should be positive: a turbine would not do. Reduced to its *simplest* form, however, such a control "system" lacks positive characteristics, loses the character of an instrument, becomes a mere "fitting" or "specialty" and has no place in this book.

Apart from rate control, there are modes of "flow control" for which positive meters are not only suitable but are obviously more suitable than rate of flow meters. Application example: a filling machine for large containers. At this writing, however, it appears that the metering devices actually used are not industrial instruments but belong to a fringe lying between the field of flow measurement and that of valves.

(c) Remote Readings

Some positive meters, especially weighers and large industrial models, are equipped with counters designed to function as the transmitters of remote reading systems (see Ch. XXVII). In adapting to such service a meter not originally designed for it, the telemetering system selected should preferably be of a dragless type. This limitation is not universal, for certain types of liquid meters under certain conditions of flow, act like hydraulic engines, so that when they are made to drive a sender, their *measuring* characteristics are not affected by the power load—except of course at extremely low rates of flow. With gas meters it is best to take no chances and select none but a dragless system.

(d) Rating

Encountered in the literature of meter manufacturers, technical writers, regulatory bodies, engineering societies, etc., this term underlies the several definitions of "size" or "capacity" but undergoes changes of meaning depending on the fluid to be metered, on the class or even the particular type of meter being considered and on the industry in which the meters are used.

One underlying consideration is the pressure loss, *i.e.*, the absorption of energy required to operate the primary device and the counter, plus the inevitable fluid friction loss resulting from the fluid's passage through ports and various other irregular passages.

Another consideration is the expected accuracy life of the meter, expressed in terms of time or in number of operating cycles. This number of cycles may be the total number, as in the case of an industrial process meter; but most frequently it is the expected number between periodical inspections multiplied by a reasonable factor. Accuracy life, analogously to "service life" of most mechanisms, depends on the wear of parts, the rate of which increases with the operating speed. A meter built to give, say, ten million cycles of operation under "normal" load (say 50% of "capacity") before it is subject to repair would probably give only two million cycles under constant maximum load. Similarly, a meter so built as to require annual inspection under normal load would have to be inspected much more frequently under overload. Here, too, as in the case of an ordinary gear train or any mechanism for the transmission of power, running the meter at *twice* the normal speed would not require *semi*-annual inspections instead of annual inspections but it would require *quarterly* inspections—if not more frequent servicing.

These two considerations, then, are intimately associated. In some cases the rating of a meter depends on both. An increase in the flow through a bellows gas meter, for example, is not only accompanied by an increase in the speed at which the valves travel over the ports, but also by an increase of the force with which the valves bear down on the ports, this being due to the increased differential or pressure-loss across the meter. With most meters of this type, this differential varies as the square of the rate of flow.

An example illustrating pressure loss as the most important consideration is found in the wholesaling and retailing of gasoline: The liquid head being low, a meter absorbing too much pressure for its operations interferes with the rapidity of the delivery. Gasoline meters, therefore, are rated on this one consideration.

An example illustrating accuracy life as the important consideration is the industrial gas meter designed for outright sale to a plant where it will not be regularly inspected by gas company men. The designers of such meters, recognizing the three-cornered relationship mentioned above—of quantity rate, pressure loss and rate of wear—have definitely limited the permissible quantity rate, and their ratings are based on this consideration.

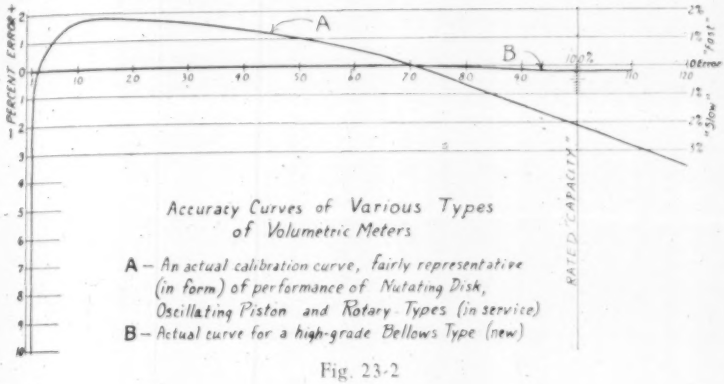
Why then is it that ordinary domestic gas meters are universally rated on the well-known ½" pressure loss? The reason is simply that the custom

originated in the early days of the gas industry when distribution pressures were so low that the pressure loss *per se* had to be the important consideration. In those days, meters could not be operated at a speed which would cause a pressure loss in excess of ½" of water, without affecting the efficiency of the appliance—especially of the mantles which were very sensitive to pressure variations.

In describing the various types we shall, where of interest to engineers, mention methods of rating accepted by the industry concerned or prescribed by bodies exercising control.

(e) Accuracy

Of all measuring properties of instruments, accuracy is the most important in the case of positive meters. Sensitivity counts little; lag and damping not at all. Readability is fairly important but requires no discussion, for meter manufacturers vie with one another in making readable counters that stay readable. The accuracy of a positive meter, namely the relation between the true value of the weight or volume passed through it and the value it registers, is expressed as usual in terms of error, but the custom is to state the "average error," not the *limit of error*, not "the maximum error by which the readings of an instrument will depart from true values."*



Accuracy Curves of Various Types of Volumetric Meters

A — *An actual calibration curve, fairly representative (in form) of performance of Nutating Disk, Oscillating Piston and Rotary Types (in service)*

B — *Actual curve for a high-grade Bellows Type (new)*

Fig. 23-2

This custom is justified by some characteristics of volumetric meters: (1) Nearly all commercial models of some types (not of all types) do not register extremely small flows. (2) All commercial models of most types show errors at excessive loads. Also, by the fact that the average consumer complains only when he believes himself overcharged, so that the service industries are more concerned over fast meters than over slow meters. In other words a gas company, for example, after stipulating that the meters it buys should be positive (should pass a "pilot" or other minimum flow registration test) insures itself against the costly loss of good will by reducing the plus or "fast" area of the average calibration curve.

Various factors bearing on accuracy were discussed in § 1 and in Art. **(d)** above. Positive meters can be used accurately over a wider range of flows, in percent of rated capacity, than can inferential meters. On the whole, then, they are *the most accurate*—class for class.

Some types slow up increasingly below 2%, stop entirely before the rate reaches zero flow, and slow up also above a point which in most cases lies between 50% and 110% of capacity. Thus their calibration curve crosses the zero error datum at two points. Curve A in Fig. 23-2 exemplifies this kind of calibration record. It is of the general form obtained when testing most commercial volumeters, but the individual curves of several meters of one maker's model may vary a little (especially at extremely low rates) while the average curves of several makes of one type and size may vary considerably—errors of 3% at normal load for one, and of 0.5% for another that resembles it outwardly.

This kind of a curve, though apparently far from the attainable ideal, is really excellent because the intersect is close to the monthly or other periodical average rate of flow of the metered fluid.

In most cases the flow rate varies between two points, at each of which the meter shows an error of different sign. If the "fast" triangular area to the left of the intersect is exactly balanced by the "slow" area to its right, the periodical reading will be exactly the volume passed through.

In other cases the flow rate is nearly constant when the meter is in use. (Example: a gasoline meter permanently installed on a loading rack, with

*Definition adopted by the Industrial Group of the Association of Scientific Apparatus Makers. See also Part One of this Manual, pages 29-33.

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NEW NEW

MANUFACTURERS' LITERATURE

In this department we each month list the printed matter issued by manufacturers. Unless otherwise noted, any of the items listed may be secured free upon application to the issuing firm. Manufacturers who have not yet sent in their printed matter are invited to do so.

335 Electric Timer. An electric timer for timing viscosity determinations and other test intervals is described in Bulletin No. 1051. C. J. Tagliabue Mfg. Co., Park & Nostrand Aves., Brooklyn, N. Y.

336 Diesel Engines. 12-page Bulletin 2266 discusses methods for testing Diesel Engines. Bacharach Industrial Instrument Co., 7000 Bennett St., Pittsburgh, Pa.

337 Circuit Breaker. Circular 1958 describes the type O "De-ion Grid" oil circuit breakers for indoor service in voltages from 15,000 to 34,500 and interrupting capacities from 500,000 to 2,500,000 kv-a; Circular 1771-B covers oil circuit breakers suitable for indoor power house installation where space is restricted. Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

338 Grade-O-Meter. A small circular describing and illustrating the Grade-O-Meter used for grading grinding wheels and other substances according to their respective structural tenacity or resistance to impact. Abrasive Engineering Co., 2842 W. Grand Blvd., Detroit, Mich.

339 Humidifier. 4-page circular describes device for both producing and controlling humidity. Southworth Machine Co., Portland, Maine.

340 Electric Timer. A leaflet announcing the Midget Interval Electric Timer model No. 42, designed for use as standard equipment on electrical appliances where space is limited and a timing range from 1 to 45 minutes is desired. Walser Automatic Timer Co., Chrysler Building, New York.

341 Manometers. A circular describing the R. S. line of U-tube manometers. The Refinery Supply Co., 621 E. Fourth St., Tulsa, Okla.

342 Signal Strength Meter. Bulletin No. 232 describes Model 232 portable outfit for locating sources of radio frequency disturbance, measuring the field strength of such disturbances, and measuring the field intensity of broadcast signals which may be affected by inductive interference. Tobe Deutschmann Corp., Canton, Mass.

343 Pressure Gages. A circular describing indicating and recording volumetric pressure gages for homogenizing and viscolizing equipment. Taylor Instrument Companies, Rochester, N. Y.

344. Microscope Equipment. Pamphlet No. 1202 illustrates special pillar stands for ultropak microscope equipment. Another piece of literature by the same company and identified as Pamphlet No. 1203 describes and illustrates immersion attachments for ultropak dry objectives. E. Leitz, Inc., 60 East 10th St., New York, N. Y. 7-7

345. Air & Gas. Air & Gas Instruments are described in pamphlet identified as Section E. .15/3011, November, 1930. Blackman Export Co., Ltd., 374 Euston Rd., London N.W.1, England. 2-08

346 Statiktester. 4-page circular describing what is said to be the only service device which measures every unit in a radio receiver and locates every defective unit when the receiver is entirely inoperative. The Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland, Ohio.

347 Fuseless Protection. Circular 1956 on the Nofuse Load Center, its application in supplying fuseless home circuit protection, diagrams of modern wiring methods. Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa.

348 Hardness Testing Machine. Leaflet on the "Superior" Brinell Hardness Testing Machine, a production testing machine with push button control and automatic features. Steel City Testing Laboratory, 8843 Livernois Ave., Detroit, Mich.

349 Midget Motors. 4-page bulletin and data sheets giving information on the different types of midget motors now available. Barber-Colman Company, Rockford, Ill.

350 Testing Instruments. 20-page Bulletin No. 9 on Pendulum Dial Load Indicator Lever Weighing System and No. 3 Type Recorder. Tinius Olsen Testing Machine Co., 500 North Twelfth St., Philadelphia, Pa.

351 Experiment. The September 1932 issue features the article, "Inexpensive Noise-Measuring Equipment." General Radio Co., Cambridge A, Mass.

352 Thermostatic Bimetal. 18-page Bulletin-N covers information on the deflection and strength of bimetal in form of a strip, helix or a spiral. The values given are for general engineering reference and are reasonably accurate for determining designs for preliminary tests. W. M. Chace Valve Co., 1602 Beard Ave., Detroit, Mich.

353 Controller. Circular 2 on the "Tour Controller" with response sensitivity of ±1°F. Lucius Pitkin, Inc., 47 Fulton St., New York.

354 Cenco News Chats. Among the feature articles in the October issue "Something New Under the Sun"; "The Cenco-Grating Spectrograph"; "A Pulmotor for Fish," etc. Central Scientific Co., 460 East Ohio St., Chicago, Ill.

355 Balances and Weights. Bulletin No. 3 describes a complete line of balances and weights used in the laboratories. Central Scientific Co., 460 East Ohio St., Chicago, Ill.

356 Humidigraph. Bulletin No. 413 illustrating a new direct-reading relative humidity recorder. The Bristol Co., Waterbury, Conn.

357 Road Surface Rater. Bulletin No. 8 describes the Olsen-Andrew Road Surface Rater and the new Olsen concrete beam testing machine. Tinius Olsen Testing Machine Co., 500 North Twelfth St., Philadelphia, Pa.

358 Searchlights. 24-page bulletin on marine incandescent searchlights. Sperry Gyroscope Company, Inc., Manhattan Bridge Plaza, Brooklyn, N. Y.

359 Bolts, Nuts and Screws. A complete handbook conveniently arranged and indexed. Also lists data regarding heads, threads, weights, etc. Clark Bros. Bolt Company, Milldale, Conn.

360 Flow Meter. A broadside illustrating a new mechanical flow meter for measuring steam, air, oil, water and other fluids. The Brown Instrument Company, 4482 Wayne Avenue, Philadelphia, Pa.

INSTRUMENTS, 3619 Forbes St., Pittsburgh, Pa.

Please have me supplied with a copy of each piece of Manufacturers' Literature listed below.

.....

.....

Name.....

Position.....

Firm.....

Street and No.....

City.....State.....

constant inlet head, etc.) Then, if this rate is, say, 70% of capacity and if that meter's curve crosses zero at 70%, it will register correctly even though the curve shows large errors to the left and right of that point.

Another general form of curve runs close to the zero error datum (individual curves "wavering" without family resemblance) down to a fraction of 1% of capacity flow, where it seems to shoot downward unless a test is run between zero flow and 2 or 5% of full load and five or six points plotted at the "angle," which is then seen to be the expected "bend." Individual meters of good makes sometimes show so little leakage and slippage under test conditions that their errors under test conditions are due mainly to the slight elastic deformations of various parts at *high* rates of flow, when the differential approaches the permissible maximum drop. Note Curve A: the meter neither slips nor leaks, so we omitted the irksome, time-consuming minimum-flow part of the test.

It should be borne in mind that the usual laboratory calibration is not a test representing extremes of service conditions. In particular, temperature variations may alter the dimensional ratios of mechanical parts whereby reciprocal motions are converted into rotation of a shaft operating a counting train; or they may seriously alter the coefficients of friction of lubricated mechanisms so that the effects of leakage transpose the "downward bend" of the accuracy curve from one point to another.

The foregoing discussion of accuracy characteristics applies to meters expected to be "accurate." It does not apply, for example, to some domestic water meters that are purchased for their cheapness and installed primarily for their moral effect in persuading citizens to save water and put off tax-increasing expansions of public works.

(f) Other Characteristics

In the case of weighers and large tank type volumeters, the initial cost is subordinated to other considerations and the running expenses are small. For liquids in pipes and for gases, most continuous volumeters cost less than most inferential types in the small sizes and more in the large sizes, this being the natural consequence of their requiring large bodies. No electric or other power being required, this item of expense does not appear, except where a meter is equipped with some special device. Similarly, no expense for charts except where a demand device is attached. Installation costs compare favorably with those of head meters. Calibration costs vary enormously.

Positive meters are usually satisfactory for measuring pulsating flow, since the weight or volume is measured directly instead of being determined as a function of a differential pressure, of a rotational velocity, or of an electrical magnitude.

When the body of a positive meter contains both the primary and secondary elements (as is usually the case) and a considerable change in the size or capacity of a pipe line is made, the entire meter must be changed.

(In connection with costs, remember that even a large positive meter costing much more than an inferential type, may be the best *investment.*)

Positive meters are preferred for commercial metering, but lately there has been a decided trend toward the use of head meters of proven accuracy and dependability for metering natural gas, oils, etc., where bills are rendered.

Nearly every gas and liquid—clean or dirty—can be measured by at least one commercial model of positive meter, at pressures up to 500 lbs. per sq. in. and in some cases higher, and at temperatures up to 400°F. and in some cases higher, but such fluid should not leave precipitates or other deposits.

Above all, positive meters are generally reliable and durable. As a class, volumeters are the most dependable of all industrial instruments having constantly-moving parts, with the possible exception of current meters as we shall see in the next chapter. Diehl asserts (*Natural Gas Handbook*) that "the gas meter is the most reliable measuring instrument made."

"It is seldom that we find a book we can so heartily recommend . . . Must be read to be appreciated."—*Heating and Ventilating*

"Done unusually well . . . A great deal of valuable and practical data . . . of much importance." — *Maintenance Engineering*

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Volumetric Pressure Gage For Use On Homogenizers

Taylor Instrument Companies

BECAUSE pressure plays such an important part in the homogenizing process, it is necessary that it be measured correctly and changes noted immediately. The ordinary Bourdon gage is not well suited to this application. Being subject to direct pressure surges it cannot remain permanently accurate and often breaks completely. It is unsanitary, as the milk or other fluid must be introduced into the spring. Water seals need daily attention and have not been successful. The ammeter type of indicator, attached to the electric drive motor, does not show the true pressure in the machine.

The Tycos Volumetric Pressure Gage for Homogenizers, specially built and adapted to the indication of pressure in homogenizers, not only may be had with a large dial, nearly 8" wide, showing pressure changes immediately, without possibility of breakage due to strain, but may also be had as a recording gage, giving a chart record of the pressure. It is completely sanitary and easy to clean.

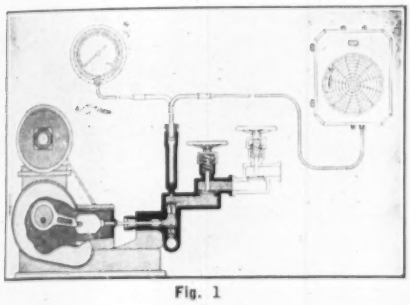
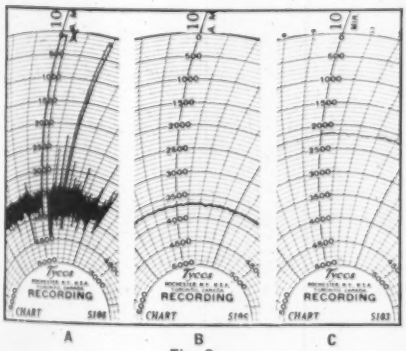


Fig. 1

The design incorporates new and patented principles in the pressure measuring field. A compressible bulb containing mercury is acted upon by the pressure in the Homogenizer, and a tube is connected to a dial indicator or recorder. As the pressure in the machine increases, it compresses the bulb, forcing the mercury through the tubing and actuating a Bourdon spring inside the instrument.

The bulb is placed in a well on homogenizers now in use (Fig. 1). New machines can be so designed by the manufacturer that the bulb can be placed directly in the high pressure chamber. In either case, the bulb can be quickly and easily removed for cleaning and sterilizing. Both the bulb and the tubing are unaffected by temperature because of automatic compensation. When it is desired to record pressures ahead of both homogenizer valves, a double record instrument can be furnished.



A B C

Fig. 2

The recorder is of the same design as the newest type of Tycos Recording Thermometer, in a handsome die-cast aluminum case with a white finish, especially fitted to dairy and other food processing equipment. The door is moisture and dust-proof. A stainless alloy pen and pen arm gives a clear ink record on a 12-hour chart.

Fig. 2 shows how useful the records are to the plant operator. Chart A shows how pressure may drop to zero, in the first case (note X on chart) because of faulty valves and in the second because of some foreign object lodged under the valves. During these periods no homogenization took place, a fact that the operator should know but which might not have been noticed with a dial type gage. B and C show proper Homogenizer operation which means proper homogenization.

◆ ◆ ◆

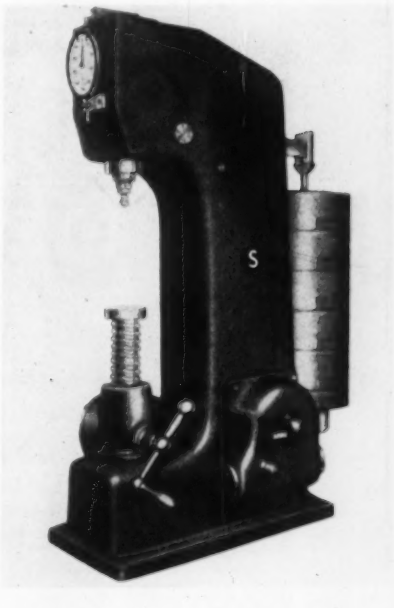
"Superior" Brinell Hardness Testing Machine

Steel City Testing Laboratory

THIS machine, the new "Superior" Model UK-300, motor driven with push button control, is an advance over previous Brinell machines in that instead of the machine being operated by hydraulics it employs the dead-weight system of applying the load. This method, as is well known, is the most positive, and it makes it possible to incorporate a depth measuring device which in conjunction with a movable scale permits hardness tests to be made quickly and read direct without the use of a Brinell microscope.

The screw table on which the specimen rests is elevated and lowered by quick crank adjustment, a decidedly quicker and easier method of performing this function.

All models of the UK-300 can be used for making Brinell tests from 250 to 3,000 kg., making the machines available for testing small specimens as well. Maximum vertical opening for specimens, 11½"; throat depth from center of specimen table to housing 4¾"; adapters of various shapes to suit the specimens can be mounted. The direct reading dial indicates in increments of 1-500 mm. for all tests.



NEW INSTRUMENTS

Recently Developed by Manufacturers

Write Information Section, Instruments Publishing Company, for additional Information.

Disk Vernier, Magnetic Damped Analytical Balances

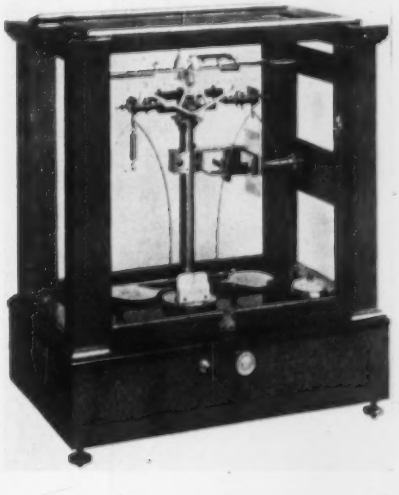
Seederer-Kohlbusch, Inc.

ADVANCES in balances in the past 25 years are perhaps less than in any other branch of precision instrument making. This is probably because analysts had little opportunity to study their most useful instrument, the balance. Its tedious, nerve-racking principle of weighing was looked upon as incurable. Even with the method of "swings" the true rest points are rarely obtained, since any or all swings may end between divisions on the index plate. Again, in precise analytical weighing, the so-called rest point must be determined before each individual weighing is made.

After a careful study of laboratory requirements, and with the cooperation of Dr. H. T. Beans, professor of Analytical Chemistry, Columbia University, the above company has developed new principles which will lighten the task of the laboratory worker. These are employed in the new "Seko" Analytical Balances.

(1) *The "Seko" Selective Magnetic Damping Device.* This device consists of a permanent magnet, mounted on a slide supported by arms affixed to the balance post. The magnet is fitted with a brass rack and pinion operated from outside the case. A graduated index inside the case shows the magnet position. A non-magnetic (aluminum) plate is suspended from the top of the balance stirrup between the arms of the magnet without touching them.

To obtain any degree of damping, within the range of the device, it is only necessary to manipulate the button on the outside. Thus each individual operator may select the degree of damping best suited to his needs. This device eliminates the tedious method of count-



ing the swings. Simply set the balance in motion and in 15 to 20 seconds the pointer stops oscillating at its true zero or load rest point.

The device does not affect the sensitiveness or accuracy of the balance even when weighing ferrous materials.

To use the balance as a free oscillating type, unhook the aluminum plate from the suspending chains, and unhook the counterbalance weight suspended from the left stirrup hook. (This is not possible with any other damping device.)

(2) *"Seko" Disc Vernier Index.* The object of this device is to eliminate the uncertainty of determining the rest point to one-tenth scale division. It is about 1¾" diameter, and is graduated into 100 equal parts, with each tenth graduation numbered 0 to 9. Each number represents one scale division, each intermediate division one-tenth scale division. It is easily read without the use of a magnifying glass or any other eyestraining device.

(3) *"Seko" Aluminum Notched Channel Beam and Sub-Beam.* With this attachment, all weighings from 1/10 mg. to 1.1 gram may be made without the use of loose weights. The sub-beam is graduated from 0 to 10 mg., in 1/10 mg. divisions, and the channel notched beam is graduated from 0 to 1.09 gram in 10 mg. divisions. Riders on both beams are manipulated, with extreme ease, by means of a single rider rod.

(4) *"Seko" Stationary Magnetic Damping Device.* This damping device is not selective, but it acts in the same manner as the selective type. It converts a balance of the free oscillating type to the dead beat principle and brings the pointer to rest in 15 to 20 seconds. It may be fitted to any make of balance without removing it from the laboratory, upon receipt of certain measurements.

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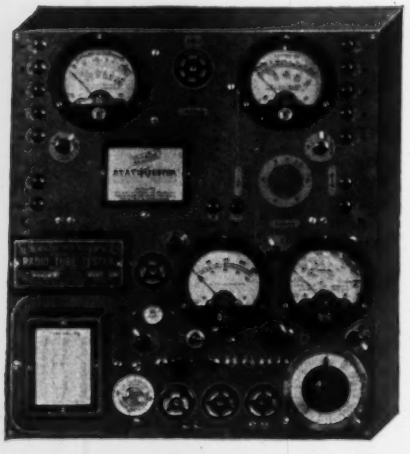
The StatiKtester

The Hickok Electrical Instrument Co.

SERVICING modern radio receivers containing a multiplicity of resistances, capacities and inductances requires that the serviceman be equipped with test equipment which will read the values of all units. The old method of simply reading socket voltages and plate current of the tube will not enable the serviceman properly to service a modern receiver.

The StatiKtester, claimed to be the first all new set tester development in years, is said to be the only service device which measures every unit in a radio receiver, and locates every defective receiver unit when the receiver is entirely inoperative.



Its universal range ohmmeter will read the values of every resistor in any receiver. The modern receiver contains a multiplicity of condensers having values from a fraction of a microfarad to several microfarads. The double range capacity meter in the StatiKtester is designed to read all the fixed condensers in a receiver, using as a source of power the a.c. supply of the tube tester.

With electrolytic condensers in modern receivers, it is necessary to read not only the capacity of the condenser, but its leakage. With the StatiKtester, the leakage and capacity can be measured under actual operating conditions.

Inductances such as transformer primaries, secondaries and choke coils are read in all values from ½ to 50 henrys. The voltages delivered to the tube socket terminals are read directly at the sockets, which eliminates loss in cords or cable; a result not obtainable where the tube is placed in the tester and the power from the chassis is carried to the tester.

All these measurements, except voltage readings, are made with the receiver not in operation, in practically all instances from the tube sockets of the receiver. Thus it becomes easy to locate an incorrect resistance, condenser or inductance value without removing the chassis from receiver cabinet, or disassembling it. Each individual unit is individually measured, and thus each individual fault is located.

Construction Details: The StatiKtester contains a triple range ohmmeter, reading all values of ohms from ½ ohm to 20 megohms. The power to operate this ohmmeter is supplied by the rectifier system of the tube tester portion. When operating on the low scale, a voltage is used of 0.2 volts; on the medium scale, 2 volts; and on the high scale, 200 volts.

The capacity meter is also fed from the transformer of the tube tester portion, and a standardized voltage of 100 volts at 60 cycles is employed. The tube tester portion measures tubes by the standardized method of applying the correct d.c. voltage to the plate and grid of the tube under test, and super-imposing upon the d.c. grid voltage and a.c. signal voltage, and reading the result a.c. component in the plate circuit which is calibrated directly in microhms, using the standard formula of $Ip/Eg = GM$.

The method of reading gas content of a radio tube in the tube tester portion is accomplished by inserting in the grid circuit of the tube under test, the high resistance of 1 megohm. If gas or ionization is present, the plate current of the tube will increase. This is then brought back to its initial value by an increase of the grid bias of the tube, proportional to gas content.

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New Metering System for Domestic Loads

Westinghouse Electric & Mfg. Co.

COÖRDINATION of three innovations making for simplified and more economical distribution of domestic load has been effected in the creation of a new metering system applicable to old systems as well as to new ones. Essentially, the plan combines a new detachable watthour meter, the "nofuze load center," and stroboscopic meter testing. It provides for mounting the detachable meter on the outside of a house exactly opposite a "nofuze load center" installed in the kitchen (eliminating long wiring runs) and for quick, convenient testing by means of a portable stroboscope.

The new meter, type OC detachable, requires no expensive meter box but the registering element is protected by a weather-proof case. Being outside it is always accessible for reading. Detachable meters eliminate postcard schemes, save the meterman's time, and promote customer good will by eliminating the necessity of interrupting the housewife's work. The meter is designed to plug into and pull out of the circuit, eliminating danger of injury to the tester. No permanently-installed test facilities are necessary because of provision for easily-carried test facilities. Elimination of test features installed at every meter saves, according to Westinghouse, approximately $1.25 per meter.

The elimination of fuses by the use of small circuit breakers mounted in a "nofuze load center" is part of the plan, affording fool-proof, easily controlled house circuit operation. To the central station it means less money spent on service calls and the customer's greater satisfaction with the service rendered, and to the home owner it means fire safety and greater convenience in his use of power.

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New Underneath Drive Precision Bench Lathe

South Bend Lathe Works

ENTIRELY new in arrangement, the drive for this lathe is by belt from a reversing motor mounted under the bench, directly beneath the headstock, providing a steady, noiseless, "down-pull" drive which insures precision. This compact, convenient and safe bench lathe can be used for turning all metals, wood, hard rubber, and compositions. It is of back-geared, screw cutting type available in 8", 9" and 11" swing size. It will cut all standard screw threads, right and left hand from 2 to 90 per inch, including 11½ pipe thread. A new index plate shows at a glance the proper gearing to obtain any desired tool feed in the wide range provided. The lathe has six spindle speeds, drum-type reversing switch, graduated tailstock spindle, automatic feeds, and precision lead screw. Belt guard for the cone pulley is optional.

Askania Controllers Sold in U. S. by Brassert

IN our September issue we reported a new temperature controller of the Askania Werke (Germany) and named the American Askania Corporation in the sub-title. This corporation informs us that H. A. Brassert & Co. hold the exclusive sales rights for Askania control equipment.

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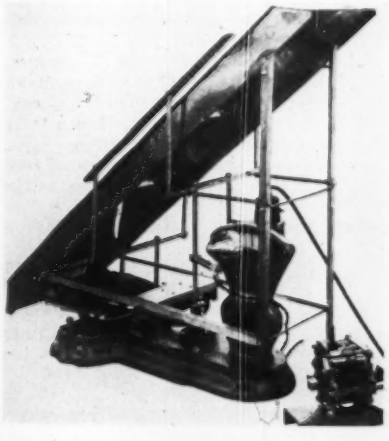
Cotton Weighing Auto-Gage

Toledo Precision Devices, Inc.

NEW speed and efficiency in the weighing of cotton bat, feathers, waste, steel wool, etc., is attained through the use of the Toledo Precision Cotton Weighing Auto-Gage. This automatic device will run continuously after the starting button has been pressed, is accurate to within 1/32 oz. and is capable of weighing, for example, 20 one-ounce bats of cotton per minute.

A micropoise counterbalance is set to cut off the desired weight. After the proper setting has been obtained, the starting button is pressed and the material starts to run onto the scale pan. As soon as the proper weight of material is on the pan, the photo-tube disengages the clutch and stops rollers through which the material passes, or the cutting mechanism may be a drop knife or some similar contrivance. Also the dimensions of the pan, the limits of accuracy and the speed can be varied. This device has proved highly efficient in operation. After starting this equipment, no attendant is necessary.



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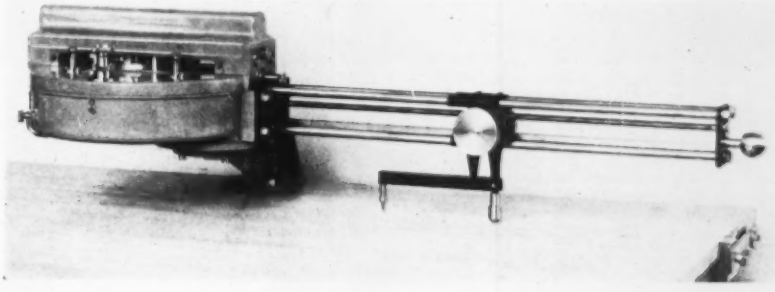
New Integrometer for Geophysical Work

American Askania Corp.

RAPID and accurate determinations of gravity gradients and other gravity data through simple integration of a cross section through a given area is made possible by this instrument. Heretofore it was very tedious to do many computations in the usual manner, with the aid of tables; and the human element made such computations rather unreliable.

The instrument consists of a large round casing resting on a rotary base. An arm is attached to the instrument so that the working range covers a large area. Knobs and counting disks are provided for proper setting. The arm attached to the casing is equipped with a rotary hand which is guided by the operator around the cross section. The Askania Integrometer is particularly applicable for torsion balance and pendulum work. The accuracy obtainable is about 5%, which must be considered entirely satisfactory for this type of work. The instrument will be of special advantage to an operating company with small geophysical staff, as well as to large geophysical departments where voluminous data have to be carefully checked and interpreted.



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New Line of Fluid Meters

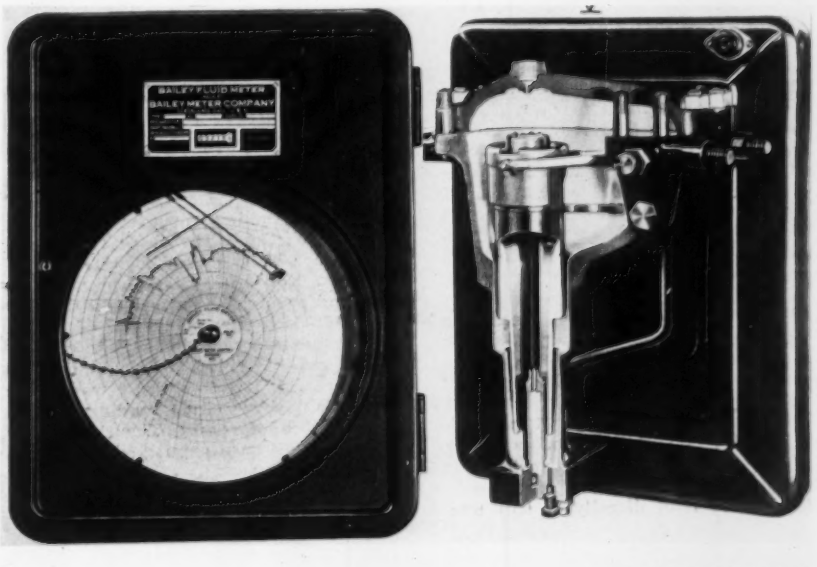
Bailey Meter Company

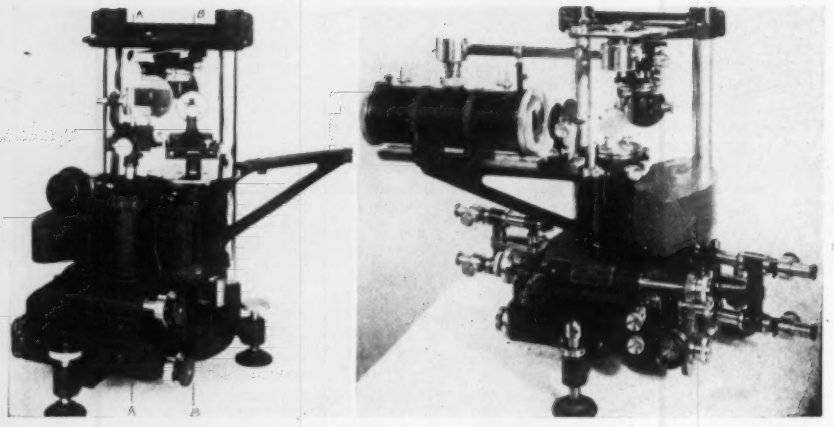
A NEW LINE of fluid meters for the measurement of steam, water, gases, and other fluids has been announced by the above company. The new meters combine accuracy and dependability with a price in accordance with 1932 conditions. Three general combinations of meters are available: indicating and integrating; recording and integrating; indicating, recording, and integrating. Fig. 1 illustrates the recording and integrating meter, suited to the majority of installations.

The record is made in pounds per hour, gallons per minute or any other desired units on a 12" diameter, 24-hour chart. Flow graduations are uniformly spaced throughout the entire range, facilitating comparison with records of pressure and temperature (obtainable on the same chart by incorporating auxiliary recorders in the meter case). Total flow is given in pounds, gallons or other units by a 6-digit counter located behind a small window in the name plate.

The simple construction is apparent from the sectional view of the differential mechanism, Fig. 2. The upstream pressure acts on the interior of the mercury-sealed Ledoux bell, and the downstream pressure is applied to the exterior of the bell, which is so shaped that its travel is proportional to the square root of the differential, hence directly proportional to the rate of flow. Guide links direct the bell in a definite path—an advantage when the meter is used for marine service or as portable equipment. By means of a forked lever and spindle, motion of the Ledoux bell is transmitted directly to the recording pen and integrator.

Permanent calibration is assured by adequate protection against sudden surges or reversals of flow. The moisture- and dust-proof pressed steel cases have been arranged to permit either "wall" or "flush" mounting. Auxiliary recorders, such as for temperature, pressure, vacuum or draft may be easily installed in the case to record these factors on the same chart with the rate of flow. Meters are available for use under any commercial operating pressure. There are no moving parts which require oiling or greasing. Use of a Warren synchronous motor for driving the integrator and chart eliminates the necessity of winding a clock. Each part is made of material most suitable for the service, therefore many special metals and alloys are employed, such as specially heat treated aluminum, monel, magnesium, cadmium plated brass, tungsten carbide, KA2 Enduro, and stainless steel.





Two New X-Ray Spectrometers

The Gaertner Scientific Corp.

ALLISON X-RAY SPECTROMETER

DESIGNED according to specifications of Prof. Samuel K. Allison of the University of Chicago, this spectrometer incorporates features which adapt it for all determinations of relative wave-length and of width and structure of X-ray lines. It differs from others in that the entrance slits are not rotable; and the second crystal table may be rotated in a planetary motion about the first crystal table which is mounted on a fixed bearing. In this manner parallel and anti-parallel crystal positions may be obtained. It therefore is possible to cover the whole X-ray spectrum without moving the X-ray tube, so that all alignments once made are preserved.

The main instrument axis *A* is a double inner and outer hard cast-iron bearing firmly attached to the base of the instrument. The *A* crystal table with its slide is mounted on a cylindrical steel shaft which bears on the inner surface. A strong counterweighted casting bears on the outer conical surface and carries the *B* crystal axis and ionization chamber arm. Ball bearing thrusts take up the greater part of the weight in both centers.

The *B* axis is a cone center with independent motions for the second crystal and ionization chamber. The ionization chamber arm is a light aluminum casting counterweighted for an ionization chamber weighing 1.5 kg.

Adjustment of crystal *A* is made by a worm and worm wheel, the worm head reading directly to 30 seconds. Crystal axis *B* is rotated about *A* by a similar worm and worm wheel reading on the circle to single degrees and on the worm head directly to 30 seconds. The position of crystal *B* relative to the *A-B* arm joining both centers may be read by a circle and vernier to one minute. In addition a tangent screw with fixed bearings and a traveling nut operating on a lever 206.2 mm. long, provides very sensitive rotation of crystal *B*, readable directly in seconds of arc. The ionization chamber support bracket is adjustable by hand, its circle reading directly to 30 minutes, by two indexes.

Two slits of the symmetric type, with lead jaws 25 mm. long, are mounted on carriages which slide along the collimator bench and may be clamped in position. **Slit width is read directly to 0.01 mm.** Necessary adjustments for centering and rotating to verticality are provided.

The crystal mounts, 50 mm. in diameter, and of improved design, may be removed to a dessicator and replaced without fear of disturbing adjustments. The crystal tables have delicate adjustments, provided with micrometer screws with divided heads, to tilt the crystal in the plane at right angles to the plane of its surface. Slide motions of improved design are provided for each crystal table in order to bring the crystal face into its axis of the instrument. Great care is taken in the design and construction to obtain exact parallelism of the two axes and so to proportion the parts as to avoid flexure.

The height of the slit axes above the feet of the instrument is about 38 cm; the distance between the two axes is 127 mm. The two worm wheels are of 228.6 mm. diameter, and the length of tangent arm for crystal *B* is 206.2 mm.

COMPTON DOUBLE X-RAY SPECTROMETER

THIS instrument, for absolute wave-length determinations, follows the latest specifications of Prof. A. H. Compton.

The *Main Casting* is massive, with 3 leveling screws 14½" apart. Two strong columns support a bracket for holding concentric with the main axis a suitable electrometer and also the collimator slit system and secondary prism table.

Pivot and Circle System: Attached to the main casting is a hollow bronze casting having on its inner and outer surfaces concentric conical bearing surfaces for the main prism table and ionization chamber respectively. The inner conical steel shaft carries the primary prism table at its upper end, and the inlaid silver circle and worm gear for driving at its lower end. The circle reads to 1 sec. of arc by two microscopes set horizontally. End thrust is taken up by a ball and spring. The arm has a dovetail slide 15" long for attachment of ionization chamber or plate holder interchangeably (each provided with suitable lead counterweight) and carries a worm gear and inlaid silver circle reading by two horizontal microscopes. Thrust is taken up by a ball race supported by an adjustable spring.

Circles, Microscopes and Accuracy: The circle is divided in 4-min. intervals, the micrometer reading directly to seconds. The worm screws for rotating the 2 circles are provided with gearing which may be thrown in or out of mesh. When in mesh the circle connected with the ionization chamber arm will rotate at twice the angular speed of the circle connected to the crystal table; micrometer heads, graduated to 20 sec. of arc, are mounted on the worm screws with an index, for the rougher reading of setting. Microscopes are provided with prisms and small electric lamps for illumination of the scale.

Primary Crystal Table: This has leveling adjustments, and a pair of cross slides for accurate adjustment of the crystal face relative to the axis of rotation of the instrument.

Bench for Slits: A second arm with inverted dovetail bench, mounted fixed on a bridge across the columns, is provided with 2 special slits with room for substituting a secondary crystal table in place of one of the slits. Because of the substantial and accurate mounting no azimuth adjustment is necessary. Slit alignment is provided for (see below) by making the slit jaws independently adjustable.

The *Secondary Crystal Table* is provided with 2 worm screws acting on a fixed graduated 4⅝" worm wheel. The worm attached to the crystal table is provided with index and micrometer head reading to 1 min.; the other worm carries a dovetail arm 8" long for mounting 2 slits and likewise reads to 1 min.

All *Slits* are provided with disk shield 3½" in diameter. The slit jaws are gold faced and are independently actuated by micrometer screws reading to 0.01 mm. The slit is adjustable to vertical by slow motion screws. Five slits are provided, 2 with long supports for the collimator when a single crystal is used, and 3 interchangeable slits with shorter supports for use when 2 crystals are used.

The *Ionization Chamber* is approx. 12½" long and 4¾" O.D.; the cylinder consists of an inner layer of brass connected to one binding post, then a layer of insulating material, and an outer layer of lead 2 mm. thick; the electrode is a 3 mm. aluminum rod; its connection to the shielded conductor to the electrometer passes through a quartz insulation; a suitable contact key is provided.

The *Photographic Plate Holder* will hold plates about 6½" long and 1½" wide, and is adjustable vertically through a range equal to the plate width, a large knurled head nut being provided on the clamping screw.

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Sodium Resisting Glass for New Light Source

Fish-Schurman Corp.

INTEREST in sodium vapor as "the light source of the future" is somewhat dampened when eager experimenters observe how quickly glass turns black when used for the new lamps. The Jena Glass Works of Schott & Gen. (represented in this country by the above corporation) have succeeded in perfecting a sodium-resisting glass, Type T-3872, which withstands also the requisite temperature. Moreover, it will seal electrodes and it possesses other desirable properties. The new glass is furnished in the forms of tubing or bulbs.

INSTRUMENTS ABSTRACTS

Abstracts on instruments and devices for measurement, inspection and control.

INSTRUMENTS ABSTRACTS, incorporated in INSTRUMENTS, is the most complete review on the subjects of measurement and control.

Abstractors cover over 700 domestic and foreign publications.

Upon receipt of the abstracts they are checked against permanent files to avoid duplication and after being rewritten to conform to our style they are classified.

Oftentimes an abstract can fit under two or even more sections. In that case we decide who will be most interested in the article, and include it under that field of reader interest. It is our aim to so arrange the abstracts that a person interested, for example, in viscosity, will keep in touch with all the important articles in his field if he reads only section 2.10. For instance, an article on "Vacuum Tube Means of Measuring Viscosity" appears under 2.10—under "Measurement and Control of Physical Properties—viscosity," although it would also fit under section (5.4)—"Electronic Devices and their Applications."

An improvement we hope to make in the Abstracts Section in the near future is the cross-indexing of articles which fit under several sections. We suggest glancing through the whole Abstract Section. This takes but a short time, and the time so taken will be found very profitably spent.

The classification number at the end of each abstract will be of assistance in mounting them on file cards.

CLASSIFICATIONS

(By Fields of Reader Interest)

MEASUREMENT TECHNOLOGY (1)
This section includes all matters concerning the art and science of measurement as follows:
Measurement Theory (1.1)
Under this heading will be included: definitions, precision of measurements, systems of units, and dimensional analysis.
Measurement Practice (1.2)
Covers Calibration and Standardization.
Calculation (1.3)
This does not include computation for instrument design, but covers calculations as a mode of measurement.
MEASUREMENT and CONTROL (2)
This section is devoted to those general measurement practices and control applications that are not confined to any one industry or branch of engineering. Thus temperature measurement and control, being of as much importance in chemical as in metallurgical processes, is a general field of interest to all industries and all branches of engineering.
Length, Angle, and Area, Including Surveying (2.01)
Time, Speed, and Acceleration (2.02)
Weight, Density, and Specific Gravity (2.03)
Pressure and Vacuum (2.04)
Flow and Volume (2.05)
Temperature (2.06)
Heat and Combustion (2.07)
Humidity and Moisture (2.08)
Power, Work, and Output (2.09)
Physical Properties, (Viscosity, hardness, elasticity, plasticity, surface tension, etc.) **(2.10)**
Liquid Level (2.11)
TESTING and INSPECTION (3)
Physical Testing and Inspection (including strength tests, bending, magnetic analysis, X-ray inspection, and other engineering test or inspection methods.) **(3.1)**
Production Testing and Inspection (This includes methods of testing and inspection for setting up production standards, grading, gaging, maintaining quality, etc.) **(3.2)**
Maintenance Testing and Inspection (Included here will be matters concerning standards and methods for controlling performance or service of equipment. Example—The problem of controlling long phone lines to give quality sound transmission would be included here.) **(3.3)**
ELECTRICITY and MAGNETISM (4)
Electrical Properties, Tests, Measurements, and Measuring Instruments (4.1)
Electrical Measuring Devices and Applications (4.2)
Magnetic Measurements (4.3)
Magnetic Properties, Materials, and their Applications (4.4)
ELECTRONICS and RADIO (5)
Radio Measurements (5.1)
Applications of Radio to Measurement and Control (5.2)
Photo-electric Measurements, Devices and Applications (including television) **(5.3)**
Electronic Measurements, Tubes, Devices, and their Applications (Under this heading would be included thermionic tubes, grid-glow tubes, thyratrons, neon discharge tubes, cathode-ray tubes, etc.) **(5.4)**
ACOUSTICS and VIBRATIONS (6)
Sound, Vibration, Phenomena and Measurements (6.1)
Sound and Vibration Devices or Applications (6.2)
LIGHT, OPTICS, and RAYS (7)
Light—General Measurements and Optical Applications (7.1)
Color Analysis, Color Matching (7.2)
Photometry (7.3)
Polarimetry (7.4)

(Continued on Page A4)

MEASUREMENT AND CONTROL (2)

Time, Speed and Acceleration (2.02)

Stroboscopic Photography. By H. E. Edgerton and K. J. Germeshausen. *Electronics*, Vol. 5, July 1932, pages 220-221.

Some advantages of intermittent light-source stroboscopes; brief illustrated description of one instrument and of its camera; diagram of one circuit. 20 photographs of a drop of milk falling on a ferro-type tin covered with a thin layer of milk, taken at rate of 180 per sec. with stroboscopic motion-picture apparatus, appear on cover of magazine.
MFB (2.02)

Process Cycle Controller. The Bristol Co. *Instruments*, Vol. 5, May 1932, page 132.

Illustrated description of new models of air-operated 4-cam and 6-cam time-schedule controllers whereby it is possible to control a process having as many as 6 independent operations overlapping or intermittent throughout the cycle.
MFB (2.02)

Weight, Density, and Specific Gravity (2.03)

Precision Specific Gravity Balance for Liquids. *Engineering*, Vol. 131, March 13, 1931, page 375.

Illustrated description. (2.03)

Coal Weigher with Electric Counter. *Power*, Vol. 75, April 19, 1932, page 600.

Coal is fed from a disk into a revolving container with 3 pockets rotating on a horizontal spindle. When the wt. of coal overbalances a counterweight, the bucket dumps and an electric contact operates a solenoid which marks up the amount of coal dumped.
AHE (2.03)

Pressure and Vacuum (2.04)

Absolute Pressure Gage. Brown Instrument Co. *Instruments*, Vol. 5, March 1932, page 85.

Illustrated description of new instrument employing a mercury-filled U-tube manometer and an electrical inductance bridge converting changes in level of mercury into electrical impulses for remote-reading.
MFB (2.04)

Precision Pressure Controller. Mason Regulator Co. *Instruments*, Vol. 5, May 1932, page 133.

Brief illustrated description of new air-operated straight-line control function device. A "rotaport synchronizer" can be quickly turned to give any desired degree of control sensitivity.
MFB (2.04)

Mercury-Arc Power Rectifier Auxiliaries and Accessories. E. S. Waterman. *General Electric Review*, Vol. 34, Apr. 1931, pages 228-234.

The rectifier is dependent on the successful functioning of its auxiliary apparatus. The exhaust system consists of a vacuum valve, mercury condensation pump, receiver tank, motor driven rotary vacuum pump and the vacuum measuring and regulating devices. The contact-making gage is made of three parts: (1) thermal vacuum detector, (2) vacuum regulator, and (3) source of excitation. The vacuum regulator consists of: (1) indicating motor, (2) regulator contacts and contact hammer, and (3) a small a.c. motor. The regulator and its auxiliary relays perform the following functions: (1) start and stop the rotary pump at desired pressures, (2) remove the rectifier from service if the pressure becomes excessive, when the unit is equipped with automatic control, and (3) sound bell alarm if pressure becomes excessive when the unit is equipped with manual control.
WHB (2.04)

Pressure Measurement in Viscous Fluids and Plastic Solids. R. V. Kleinschmidt. *Chemical & Metallurgical Engineering*, Nov. 1930, page 702.

Chief difficulty is that plastic or semi-fluid materials themselves can not be used to transmit pressure through small tubes. To overcome this difficulty, a suitable pressure transmitting fluid, such as water or oil, is employed.
MS (2.04)

Measurement of Pressure in High-Power Circuit Breakers. (Druckmessung an Hochleistungsschaltern.) W. Kaufmann. *Archiv für Technisches Messen*, 1931, section V133-2, page T7.

The suppression of the arc in an oil circuit breaker causes evaporation and high pressure. The pressure can be measured by means of lead-diaphragm, carbon pile, condenser, piezo-electric or variable-inductance gages. These methods are described.
Ha (2.04)

Built-in Gas-Pressure Regulator. (Der in das Gerät eingebaute Gasdruckregler.) Walter Brümmerhoff. *Das Gas- und Wasserfach*, Vol. 75, Apr. 23, 1932, pages 317-323.

The principle of the new built-in regulator is described. Graphs show its value.
MAB (2.04)

Gas Pressure Regulator for Houses, Dwellings, or Gas Meters. (Gasdruckregler für Haus, Wohnung oder Gasgerät.) Gerhard Florin. *Gas- und Wasserfach*, Vol. 75, Jan. 2, 1932, pages 12-13.

Describes layout and devices used by the gas company at Nordhausen, Germany, parts of which city are at quite different levels.
MAB (2.04)

The Control of Feedwater Pressure to Individual Boilers. V. V. Veenschoten. *Steam-Plant Engineering*, Vol. 1, May 1932, pages 30-32.

Valve maintains constant pressure drop across feedwater regulator valve, thus making flow through the valve directly proportional to the area of opening, regardless of changes in feed line pressure.
AHE (2.04)

Automatic Remote Gas Pressure and Volume Limit Control. *Iron & Coal Trades Review*, Vol. 124, Feb. 12, 1932, page 280.

An electro-hydraulic regulating arrangement for the distribution of a fluctuating gas supply to the various sections of a large works is described.
Ha (2.04)

You Cannot Fool a Pressure Gage but it can Fool You. Bill Toboldt. *Automobile Trade Journal*, Nov. 1931, page 34.

Points to keep in mind when checking compression to determine condition of valves, pistons and rings.
(2.04)

Vibration Eliminator for Pressure Gages. *Power*, Vol. 75, Feb. 17, 1931, page 309; Vol. 75, Feb. 23, 1932, page 282.

Describes a "pressure snubber."
AHE (2.04)

Spectrometry (7.5)
Photography (7.6)
Microscopy (7.7)
Electromagnetic Rays (This heading covers all electromagnetic rays other than visible light: infra-red, heat rays, ultra-violet, X-rays, alpha, beta, gamma, cathode, and cosmic rays.) **(7.8)**

CHEMISTRY (8)
Under this heading will be chemical measurements, analysis, and their control applications.

ASTRONOMY, NAVIGATION, AVIATION (9)
Included in this section will be, besides usual matters concerning astronomy, navigation and aviation, special matter on direction-control such as range finding, direction finding, radio beacons, etc.

GEODESY, GEOLOGY (10)
In this section will be covered seismology, geophysical prospecting methods, etc.

INSTRUMENT DESIGN and CONSTRUCTION (11)
Matters concerning new instruments, their design, operation and manufacture, will be included under this heading.

GENERAL and MISCELLANEOUS (12)
This section will include: First; general items of interest to all in the field of measurement and control. Example—"Possibilities of Vacuum Tubes for Application to Measurement and Control" is an article of universal interest in the fields of measurement and control. Second; miscellaneous items of general interest because not includable under any of the above classifications. Finally, items of general interest to all fields of measurement and control, such as historical material, biographical, etc.
General (of interest to all in measurement or control fields) **(12.1)**
Miscellaneous (12.2)
Historical and Biographical (12.3)
Bibliographical (12.4)
Economic (12.5)

CONTROL FUNCTIONING EQUIPMENT (13)
Literature on the equipment used by operators or automatic controllers to perform their control functions will be covered under this heading. For example, the drum controller and associated switches, rheostats, relays, and motor starters by which an operator controls the motion of a crane are all pieces of "control functioning equipment."
Mechanical Control Functioning Equipment (13.1)
Electrical Control Functioning Equipment (13.2)
Includes drum controllers, relays, solenoids, etc.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., REQUIRED BY THE ACT OF CONGRESS OF AUGUST 24, 1912

of INSTRUMENTS, published monthly at Pittsburgh, Pa., for October, 1932. State of Pennsylvania, County of Allegheny, ss.

Before me, a Notary Public in and for the State and county aforesaid, personally appeared Richard Rimbach, who, having been duly sworn according to law, deposes and says that he is the publisher of the INSTRUMENTS and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 411, Postal Laws and Regulations, printed on the reverse of this form, to wit:

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RICHARD RIMBACH, Publisher.

Sworn to and subscribed before me this 23d day of September, 1932. [Seal] E. T. CHANCE, Notary Public.

(My commission expires March 7, 1933)

"Newbridge" Service Pressure Governor. *Gas Jour.*, Vol. 197, Mar. 2, 1932, page 537.

Cast iron body contains 2 cylinders of different [illegible] lower provided with hardened stainless steel liner, contains a ported Cr plated piston which acts as the governing valve. The oil-immersed pressure control piston in the upper cylinder takes the place of the usual leather diaphragm or mercury bell. Leaks or blowouts cannot occur. An ejector nozzle provides automatic pressure compensation [illegible] as the volume of gas passing through the governor is increased, the governed pressure also increases slightly to compensate for loss of pressure in the house service pipes. MAB (2.04)

Selsyn-Operated Pressure Gage. *Power*, Vol. 73, Apr. [illegible] page 567; Vol. 75, Feb. 23, 1932, page 281.

As the driven Selsyn assumes a definite position for each pressure so do Selsyn-operated indicators and recorders. AHE (2.04)

Pilot-Valve-Controlled Reducing Valve. *Power*, Vol. 73, Apr. 14, 1931, page 602; Vol. 75, Feb. 23, 1932, page 310.

To prevent lowering of supply pressure below a fixed minimum by excessive demands for process steam, only steam in excess of 125 lb. pressure is allowed to pass to the low-pressure system. A connection transmits the reduced pressure of 25 lbs. through a pilot valve to the upper surface of a regulator diaphragm, which is balanced by a mercury column of sufficient height to exert a pressure of 25 lbs. on the lower surface. The regulator maintains 25-lb. reduced pressure as long as the supply or boiler pressure is above 125 lbs. AHE (2.04)

Gage for Low Pressure and Vacuum. *Power*, Vol. 73, June 16, 1931, page 970; Vol. 75, Feb. 23, 1932, page 285.

An improved Hg column gage for pressures up to 26 lb. and for vacuum gives better visibility than usual to the Hg and greater distinctness to the scale. AHE (2.04)

Gage Protector and Non Pulsator. *Power*, Vol. 74, Aug. 4, 1931, page 178; Vol. 75, Feb. 23, 1932, page 282.

Brief description. AHE (2.04)

Pilot Controller. *Power*, Vol. 74, Aug. 18, 1931, page 250; Vol. 75, Feb. 23, 1932, page 311.

The change of the leak of the operating medium (air or gas) is accomplished by the varying position of a Bourdon tube. By change of tubes, pressures up to 2500 lb. can be handled. The design is especially adopted to reduced pressure, back pressure, boiler gas fuel and vacuum control. AHE (2.04)

Liquid-Level Gage. *Power*, Vol. 74, Sept. 29, 1931, page 475; Vol. 75, Feb. 23, 1932, page 283.

Description of a mercury U-gage. AHE (2.04)

Multi-Contact-Making Pressure Gage. *Power*, Vol. 74, Oct. 13, 1931, page 546; Vol. 75, Feb. 23, 1932, page 282.

Ten adjustable contacts can be located at predetermined intervals over the scale of this pressure gage. AHE (2.04)

Gage Pulsation Dampener. *Power*, Vol. 74, Oct. 20, 1931, page 582; Vol. 75, Feb. 23, 1932, page 282.

General. AHE (2.04)

All-Steel Gage for Severe Service. *Power*, Vol. 74, Nov. 3, 1931, page 655; Vol. 75, Feb. 23, 1932, page 281.

A rugged gage resistant to many chemicals and fumes (S, NH_3, etc.) is described. AHE (2.04)

Non-Recording Pressure Control Instrument. *Power*, Vol. 74, Nov. 10, 1931, page 689; Vol. 75, Feb. 23, 1932, page 309.

Describes a pressure controller, range from 0 to 5000 lbs./in^2. AHE (2.04)

Constant Pressure for Hydraulic Regulators. H. M. Spring. *Power*, Vol. 74, Nov. 17, 1931, page 705.

Descriptive. AHE (2.04)

Bypass Relief Regulator for Pressure Control Valve. *Power*, Vol. 75, No. 10, March 8, 1932, page 383; *Steam Plant Engineering*, Vol. 1, No. 3, March, 1932, page 50.

A 2-way relief, developed by the Northern Equipment Co. to safeguard the actuating element of a pressure control valve against excessive unbalanced pressures, is described and illustrated. AHE (2.04)

Absolute-Pressure Gage. *Power*, Vol. 75, May 3, 1932, page 673.

A standard Brown inductance bridge manometer is used. AHE (2.04)

Flow and Volume (2.05)

Non-Recording Flow Controller. Neilan Co. *Instruments*, Vol. 5, May 1932, page 132.

Brief illustrated description of new flow control device wherein differential actuates fully-balanced compound pilot valve. Convertible from one range to another. MFB (2.05)

Slot Weirs and Orifice Meters. Vulcan Copper & Supply Co. *Instruments*, Vol. 5, June 1932, page 162.

Illustrated descriptions of new devices for small and medium flow-rate liquid metering. MFB (2.05)

The "Ernst Eickhoff" Gas Meter. (Die Gasmessmaschine der Firma Ernst Eickhoff, Wuppertal.) *Das Gas- und Wasserfach*, Vol. 74, May 9, 1931, pages 431-432.

Due to its small size, oil may be used as the confining liquid, with its attendant advantage of freedom from corrosion. The adoption of the piston eliminates pressure fluctuations during working and renders its indications independent of the level of the filling liquid, while no unregistered gas can pass, and deposits from the gas cannot interfere with its operation. Since patents are pending in different countries, no diagrams can be published. It is a high capacity (70,000 cu. ft. per hr.) meter of small size. Reviewed in *Gas World*, Vol. 96, Jan. 30, 1932, page 108. MAB (2.05)

Meters and Un-accounted for Gas. "Meteor." *Gas World*, Vol. 95, Dec. 19, 1931, page 629.

Plea for the registration of all leaks, whether in station meter or service meter. The effects of corrosion by gas, discrepancies in district meters which produce a static leakage and non-registration of internal leakages should all be taken into consideration. MAB (2.05)

Meter for Acids. *Chemical & Metallurgical Engineering*, Dec. 1930, page 767.

Simple flow meter for corrosive liquids may be constructed from a glass bottle from which the bottom has been removed. A lead cover burned to a lead inlet pipe is placed over the bottle, and a lead flow deflector at the bottom of the inlet pipe. Flow rate marked on a scale calibrated by actual measurement. MS (2.05)

Design and Manufacture of Dry Gas Meters. E. Butterworth, *Gas Journal*, Vol. 197, Mar. 16, 1932, pages 681-688.

Paper read before Manchester and District and Yorkshire Junior Associations, joint meeting, Stretford, March 9, 1932. General review of the development of the design of the dry gas meter since 1820, giving special attention to the standard meter, the high-capacity meter, the treatment of diaphragm leathers, the deposits on valve faces as they affected design, and the careful maintenance of high standards obtained by accurate specifications. MAB (2.05)

Damping U-Tube for Flow Meters. *Power*, Vol. 73, Feb. 3, 1931, page 202; Vol. 75, Feb. 23, 1932, page 282.

A brief description is given. AHE (2.05)

Draft Gage for Zoned Air-Flow Control. *Power*, Vol. 74, July 21, 1931, page 106; Vol. 75, Feb. 23, 1932, page 283.

A compact gage with a tandem arrangement of differential elements is described. AHE (2.05)

Ratio Meter for Gas and Oil Firing. *Power*, Vol. 74, Sept. 8, 1931, page 370; Vol. 75, Feb. 23, 1932, page 280.

A flexible meter for a combustion guide is described. AHE (2.05)

Differential Limit Controller. *Power*, Vol. 74, Sept. 22, 1931, page 441; Vol. 75, Feb. 23, 1932, page 311.

This controller cuts in automatically additional make-up in industrial process plants when the differential falls below a set point and vice versa. AHE (2.05)

Electrically Operated Orifice Meter. *Power*, Vol. 74, Dec. 29, 1931, page 949; Vol. 75, Feb. 23, 1932, page 279.

Describes Type EB Orifice meter and its electrical remote-reading system, based on balancing of 2 similar circuits. AHE (2.05)

Small-Capacity Condensation Meters. *Power*, Vol. 75, Jan. 12, 1932, page 76; Feb. 23, page 273.

Rotary meters, containing 6 identical buckets locked in position at the rotor axis with capacities of 250 and 500 lbs./hr. are described. As the buckets are filled the weight of the condensate causes rotation. AHE (2.05)

Zoned Air Control for Stokers Made Automatic. F. J. Chatel, *Power*, Vol. 75, Jan. 26, 1932, pages 121-124.

The tuyère section of Delray No. 3 stoker is divided into 4 general zones and an individual windbox and air duct supplies preheated air to each of the 4 sections on each of the 15 retorts. In the windbox are an orifice and a control damper of the balanced cylindrical type. Air enters at each end and is throttled through the slots in the cylindrical surfaces. The orifice does the metering and the control damper regulates air volume. The pressure differential across the orifice is maintained practically constant throughout the operating range of the boiler by varying the area of the orifice in proportion to the load demand. All orifices are linked together and operate simultaneously by a mercury-sealed motor mechanism responsive to the differential between the windbox and atmospheric pressures. Weights are adjusted to give orifice openings in proportion to the windbox pressure. Each control damper is operated by an individual motor mechanism balanced by a deadweight for a predetermined orifice differential. Any change in air flow due to change of fuel bed thickness causes a corresponding change in orifice differential, which unbalances the motor mechanism causing it to operate the control damper until the original differential pressure is restored, thereby maintaining a constant air volume. AHE (2.05)

High-Range Manometer. *Power*, Vol. 75, Feb. 16, 1932, page 255.

The Meriam high-range manometer is described and illustrated. AHE (2.05)

Adjustable Orifice for Fluid Meter Installations. *Power*, Vol. 75, March 22, 1932, page 453.

An adjustable orifice gives flow range of 40 to 1 without interrupting meter operations. AHE (2.05)

Ring-Balance Flow Meters. *Power*, Vol. 75, Apr. 26, 1932, page 637.

Description of tilting-manometer type of secondary element. AHE (2.05)

Improved Anemometer for Low Velocities. Arthur M. Hill, *Power*, Vol. 75, March 15, 1932, page 409.

Descriptive. AHE (2.05)

Insuring Accuracy of Steam-Flow Meter Readings. M. F. Knox. *Power*, Vol. 75, May 3, 1932, pages 654-655.

Among causes of errors discussed are leaky condensers or partial obstruction of the orifice by scale, salt deposits, erosion, corrosion, etc. The method of calculating and constructing a calibration chart for varying temperatures and pressures is described. AHE (2.05)

Indicating Meters for Liquids and Gases. *Power*, Vol. 75, May 10, 1932, page 709.

A free top-shaped float is held in suspension by the upward flow in a vertical transparent tube which is calibrated to show rate of flow. AHE (2.05)

Model GA Water Meter. *Power*, Vol. 75, June 14, 1932, page 901.

New Worthington positive displacement disk type. All register gears are fitted with rubber bushed bearings. AHE (2.05)

High Differential Flow Meters. *Steam-Plant Engineering*, Vol. 1, June 1932, page 49.

A flow meter for high differentials and adapted for metering high pressure steam at the high velocities generally employed in modern high pressure plants is described. The primary element is a plate orifice or flow nozzle; the secondary element is a tilting U-tube suspended on a knife edge and controlled by a metallic ribbon pressing against a cam so shaped that the inclination is proportioned to the rate of flow. AHE (2.05)

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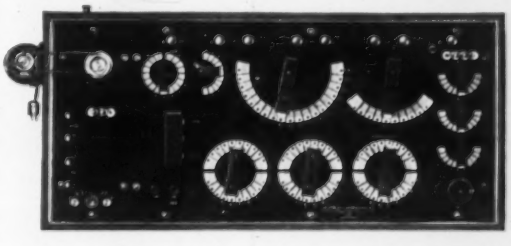

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SCIENTIFIC INSTRUMENTS

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Study on Thermostat. II. Research on Electric Relay of Thermostat and Spark in Thermoregulator. S. KAMBARA and M. MATSUI. *The Journal of the Society of Chemical Industry, Japan,* Vol. 34, Mar. 1931, pages 94B-99B.

Trial relay is constructed by electric magnet winding enamelled wire (42.B.S.) 20,000 turns and a neon lamp in series. Lamp is non-inductive high resistance to reduce consuming current under the limit, and effects to refuse induced current to flow into the thermoregulator and acts as pilot lamp. As such it needs no auxiliary battery or amplifier set out to cut off a circuit loaded 1 kilowatt. As a source of circuits of loads, 100 cols A.C. or D.C. may be good. Consuming currents is 4-8 ma. at 100 volts, to make spark in thermoregulator disappear at all. Mercury is removed from strain by sparking and capillary tube is made finer, elevating the accuracy and constancy of thermostats. Relay is covered by Japanese patent and is manufactured by Jukungag Scientific Instrument Factory, Tokyo.
MAB (2.06)

Study on Thermostat. III. Research on Time Lag of Various Thermometers. SHUU KAMBARA and MOTOTARO MATSUI. *The Journal of the Society of Chemical Industry, Japan,* Vol. 34, May 1931, pages 167B-172B.

Explanation of the time lag and of previous method of determination. Principle of the new method of determining lag; apparatus and experimental procedure; observations and results; summarizing statement; table. MAB (2.06)

Calibration of Beckmann Thermometer. II. Precise Calibration of Graduation Scale. MOTOTARO MATSUI and KATSUJI MIYAMURA. *The Journal of the Society of Chemical Industry, Japan,* Vol. 34, June 1931, pages 200B-202B.

The precise calibration was performed on the same instruments as used in Part I. The Gay-Lussac Method and the Neumann-Theisen Method were used. A correction table is given. MAB (2.06)

Heat Meters. (Wärmemengenmesser.) H. NETZ. *Archiv für Wärmewirtschaft und Dampfkesselwesen,* Vol. 12, Dec. 1931, page 345.

Compares the chief designs of heat meters: the dilating thermometers with and without valves, meters with resistance thermometers, and meters with automatic current regulators. MAB (2.06)

Some Notes on the Application of Direct Acting Thermostats to Industrial Appliances. *The Gas World, Industrial Gas Supplement,* Vol. 96, Mar. 19, 1932, pages 17-18.

Deals with the advantage in having low-cost temperature control for various processes: hardening of aluminum (where the action of the thermostat is steady and will turn off the gas before the highest temperature needed is reached), drying of cores in iron foundries, and washing machines for finished castings where the hot water swilling used in a plating shop is regulated. MAB (2.06)

High Temperature Conversion Chart. *American Machinist,* Vol. 76, Jan. 7, 1932, page 33.

Gives a comparative scale of F. and C. (F. range is from 0 to 6500°, C. from 0 to 3600°), conversion formulas, and a table showing relationship of watt-hour, B.t.u., calorie, H.P. and raising of 1 lb. of water 1°C. per hour. RHP (2.06)

Compensated Tubing for Temperature Recorders. *Power,* Vol. 73, Apr. 21, 1931, page 642; Vol. 75, Feb. 23, 1932, page 280.

The volume of Hg in the tubing is so proportioned to its coefficient of expansion and to the size of the alloy wire that any change in the volume of Hg resulting from external temperature changes is compensated. AHE (2.06)

Potentiometer Pyrometer. *Power,* Vol. 74, July 28, 1931, page 140; Vol. 75, Feb. 23, 1932, pages 279-280.

Charts and scales conform to the latest calibration values of Fe-Constantan, Chromel-Alumel, and Pt-Rh thermocouples. A humidity compensator automatically brings the pen into proper register with the chart markings. AHE (2.06)

Electric Vapor Motor for Heating Control. *Power,* Vol. 74, Sept. 15, 1931, page 406; Vol. 75, Feb. 23, 1932, page 273.

Electric current supplied to the heating element of the Cook electric vapor motor vaporizes a small quantity of liquid in the bulb. The vapor in expanding drives the remaining liquid out of the vaporizing bulb into the housing, forcing the flexible bellows to contract. This moves the drive shaft. The timing can be varied by varying the heating element and the volatile liquid. AHE (2.06)

Improved Potentiometer Pyrometer. *Power,* Vol. 74, Sept. 29, 1931, page 476; Vol. 75, Feb. 23, 1932, page 281.

A new mechanical balancing device and an automatic standardizer which checks the instrument every 45 min. have improved the L. & N. potentiometer. AHE (2.06)

Thermometer Gives True Bulb Temperatures. *Power,* Vol. 74, Dec. 15, 1931, page 877; Vol. 75, Feb. 23, 1932, page 280.

Freedom from the effects of temperature fluctuations around tube and head are claimed for a recording thermometer. AHE (2.06)

Thermostatic Radiator Valve for Steam Heating System. *Power,* Vol. 75, March 15, 1932, page 417.

General. AHE (2.06)

New Temperature Control. *Power,* Vol. 75, Jan. 26, 1932, page 148; Feb. 23, page 273.

New temperature controller (Superstat) available in 2 forms: a damper-type regulator having an operating arm which moves through an arc of 90°, and a valve modulator mounted directly on a globe valve for complete closure or on a butterfly-type valve for intermediate flow control. The lever unit has a lifting power of 12 lb. on the arm and the valve device can handle a 4 in. valve on low pressure. The control is powered by a reversible squirrel-cage motor and is designed to move in either direction upon $\frac{1}{8}°$ temperature change. AHE (2.06)

Pyrometry as Applied to Liquid Steel. *Fourth Report of the Heterogeneity of Steel Ingots, Iron & Steel Institute, Advance Copy,* May 1932, pages 100-128.

Laboratory and plant tests showed that the disappearing filament type of optical pyrometer was superior to the polarizing type. It is suggested that better fillers should be used in disappearing-filament type pyrometers. JLG (2.06)

THE
REVIEW OF SCIENTIFIC
INSTRUMENTS

F. K. RICHTMYER, *Editor*
Cornell University, Ithaca, N. Y.

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The Design of Temperature Control Apparatus for Piezo Oscillators. VICTOR J. ANDREW. *The Review of Scientific Instruments*, Vol. 3, July 1932, pages 341-351.

The procedure is described for calculating the dimensions of the different components of a temperature control system consisting of conducting and insulating layers outside the thermostat, and absorbing, and in some cases insulating layers between the thermostat compartment and the quartz plate mounting. A method is explained for observing and empirically reducing the effect of variations of room temperature on the controlled temperature of the apparatus. This effect depends on the relative positions of the thermostat, the heater, and the quartz plate. It is usually the limiting factor in precision of control. (2.06)

Pyrometers in Blast Furnace Practice. CHARLES E. FOSTER, *The Iron and Steel Industry and British Foundryman*, Vol. 5, Dec. 1931, pages 141-147, 153.

Advantages and disadvantages of the various types of instruments: expansion thermometers, electrical pyrometers, resistance pyrometers, thermo-electric pyrometers, and optical and radiation pyrometers. CHL (2.06)

Heat and Combustion (2.07)

Portable CO_2 Meters. DEFENDER AUTOMATIC REGULATOR CO. *Instruments*, Vol. 5, May 1932, page 135.

Descriptions, 3 photos, 1 diagram, of new indicating and recording gas-analysis instruments. MFB (2.07)

The Technical Control Equipment of the Boiler Works of a Large Power Plant. (Die messtechnischen Einrichtungen der Kesselanlage eines Grosskraftwerkes.) H. ROENTSCH. *Archiv für Wärmewirtschaft und Dampfkesselwesen*, Vol. 13, Apr. 1932, pages 85-88.

Basis for the size of the testing equipment, supervision of furnace, means of protecting from high temperatures in the furnace room, the amount and temperature of the boiler water, the composition of the waste gases, control and observation equipment, etc., are considered. MAB (2.07)

Combustion Regulators in the Steam Power Plant of the Municipal Works A. G. Kassel (Feuerregler in Dampfkraftwerk der Stadtische Werke A. G. Kassel). *A E G Mitteilungen*, Apr. 1932, pages 133-136.

A main regulator controls the individual regulators of 10 boilers and secures the proper amount of combustion air for each unit according to its load and condition of fire. The savings made by this installation against the previous method where the total air for all boilers was only regulated without regard to individual requirements amounted to 3% of the total coal bill, the investment of RM 2000 was repaid in less than a year. The arrangement and performance of the regulators is described. Ha (2.07)

Errors in the Sampling of Coal from Wagons. N. SIMPKIN. *Journal of the Institute of Fuel*, Feb. 1932, pages 212-215.

Concludes that car sampling of dry slacks by the British Engineering Standards Association specification shows too high an ash content and too much fines. Only satisfactory method found so far is to take increments as cars are being filled or emptied. In latter case, increments must be taken throughout unloading period because coal segregates in each car, coarse sizes at the bottom and sides, fines in the middle and on top. MS (2.07)

Automatic Remote Control of Boilers; With Remarks on the Selection of Boiler Room Electrical Apparatus. J. W. YOUNG. *Journal of the Institute of Fuel*, Feb. 1932, pages 217-223.

Gives principles of steam generation and outlines necessary instruments and control equipment. Describes principal features of an all-electrical all-British system of automatic control. To maintain constant pressure, a sensitive master regulator adjusts fuel feed and air flow. To maintain complete combustion, air flow is controlled by direct comparison of the readings of indicating steam and air flow meters. Steam-flow air-flow ratio can be made to follow a pre-determined curve (which can be modified to suit changes in coal or variations in boiler condition) and furnace pressure is adjusted at the same time by controlling the forced-draft fans. Load is divided between several boilers operating in parallel by arranging balanced relays between the steam flow on the boilers with rheostats, the relays acting on the stoker motors. MS (2.07)

Physical Properties (2.10)

P. C. E. Furnace. THE DENVER FIRE CLAY CO. *Instruments*, Vol. 5, May 1932, page 129.

Description and diagram of new high-temperature bench furnace for evaluating clays. Burns artificial or natural gas, or propane, and with a small amount of oxygen cone 39 can be brought down. MFB (2.10)

Firestone Penetrometer. AMERICAN INSTRUMENT CO. *Instruments*, Vol. 5, May 1932, page 129.

Brief illustrated description of commercial realization of instrument giving direct dial indication of resistance of rubber, etc., to penetration. (See also *Industrial & Engineering Chemistry*, Vol. 20, Feb. 1928, page 216.) MFB (2.10)

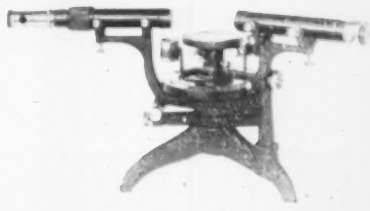
Direct-Reading Ebulliometer. C. J. TAGLIABUE MFG. CO. *Instruments*, Vol. 5, May 1932, page 134.

Brief illustrated description of new apparatus which gives a direct reading of the alcohol content of a liquid. The principle is based on the change of boiling point with change in alcohol content. Both the water and the liquid under test are subjected to boiling point temperature simultaneously. MFB (2.10)

Vogel-Ossag Viscometer. AMERICAN INSTRUMENT CO. *Instruments*, Vol. 5, June 1932, page 164.

Description, diagram, of instrument whereby both kinematic and absolute viscosities may be obtained by direct measurement. Engler, Redwood, and Saybolt viscosities may be obtained by means of a conversion table supplied. MFB (2.10)

L101 SPECTROMETER STUDENT MODEL



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Accelerated Method for Determining Creep Limit. A. Pomp and Walter Enders. *Instruments*, Vol. 5, July 1932, pages 166-168.

Authors are with Kaiser Wilhelm Institut fur Eisenforschung, Dusseldorf. Paper gives first a brief introductory explanation; describes new apparatus, and reports results. Creep testing machine has salt-bath furnace heated by bifilar winding of Cr-Ni ribbon. Elongation of specimen automatically recorded on drum chart by photographic adaptation of standard Martens mirror extensometer. Photo and 2 diagrams of machine; 9 figs. of records. Method of evaluation from records is explained; reasons for time intervals selected are given. Conclusion is proposal that creep limit be max. load for which, in time interval between 5th and 10th hour, elongation rate of 0.003% per hour is not exceeded. MFB (2.10)

New Portable Sheet Metal Tester. Detroit Testing Machine Co. *Instruments*, Vol. 5, July 1932, page 179.

Brief illustrated description of new device, using standard cup tester. An ordinary bench vise is used for holding the instrument and applying the pressure. MFB (2.10)

Universal Testing Machines. Steel City Testing Laboratory. *Instruments*, Vol. 5, July 1932, page 180.

Brief illustrated description of new machines. Capacity 22,000 lbs. Hand or motor drive. MFB (2.10)

Corrosion Testing Machine. Westinghouse Electric & Mfg. Co. *Instruments*, Vol. 5, July 1932, page 180.

Brief illustrated description of new machine which alternately immerses and raises the samples (suspended by glass hooks, etc.) at pre-determined rate of cycling. Corrosive bath temperature is controlled. MFB (2.10)

An Electrically-Heated Melting Point Apparatus. Charles E. Sando. *Industrial Engineering Chemistry, Analytical Edition*, Vol. 3, Jan. 15, 1931, page 65.

The apparatus consists essentially of an electrically-heated modified Thiele-Dennis melting point tube. MEH (2.10)

Measurement of Abrasion Resistance. I—Paints, Varnishes, and Lacquers. A. E. Schuh and E. W. Kern. *Industrial Engineering Chemistry, Analytical Edition*, Vol. 3, January 15, 1931, pages 72-76.

Presented before the Division of Paint and Varnish Chemistry at the Cincinnati meeting of the American Chemical Society, Sept. 1930. A method of measuring abrasion resistance of materials in the form of thin films has been devised. It is useful also in the study of a wide range of other materials. MEH (2.10)

The Phenomenon of Slip in Plastic Materials. A. Nadai. Reprint of Paper read at June 24, 1931, Annual Meeting of A. S. T. M. *Proceedings A. S. T. M.*, Vol. 31, part II, 1931, 36 pages.

Recent improvements in design and in manufacturing processes are due to a better knowledge of the permanent or plastic deformations of the ductile metals. Plasticity has been recognized as one of the general properties of solid matter, which can be utilized in a number of manufacturing processes. In metals, in minerals and rocks, most interesting evidences of regular structural changes have been found after exposing these materials to severe plastic strains and deformation. In the description of the states of equilibrium in loose granular materials and of the plastic state under which metals flow in the testing laboratory—and solid rocks have apparently been severely deformed in great depths on a large scale in nature—an attempt has been made to explain certain frequently observed phenomena connected intimately with the limiting conditions of equilibria and to treat these latter from common points of view in idealizing certain properties of solid matter. On metal or rock specimens subjected to severe stressing, faint traces of locally concentrated deformations in thin layers have been observed. Frequently in these thin layers visible on the surface of a test specimen, a pattern with great regularity is disclosed. The strange laws under which they appear have recently attracted the mathematicians. These regular markings might offer useful means to study the distributions of stress under which they were produced. To these thin plastic layers, quite analogous phenomena seem to correspond in geology on a large scale. In a greater number of examples, taken from practical applications in engineering design and from the branch science of structural geology, the laws of the formation of the slip lines and of the plastic layers have been studied. A new optical bench has been designed by the author, which serves to demonstrate and to study the formation of the plastic slip layers in test specimens, with a high degree of accuracy. 40 illustrations. (2.10)

The Dielectric Constant of Water as Determined by a Resonance Method. E. P. Linton and O. Maass. *Journal American Chemical Society*, Vol. 53, March 1931, pp. 957-964.

The resonance method for the measurement of dielectric constants as described by Cuthbertson and Maass has been re-investigated. A method for calibrating condensers, which vary in a linear manner according to their setting, is described. The effect of the power of the oscillating circuit has been examined and the precautions necessary in dealing with media of high dielectric constants have been specified. MEH (2.10)

A Photographic Method for the Determination of the Resistance of Gasoline to Detonation. (Sur la détermination par la méthode photographique de la résistance des essences à la détonation.) M. Aubert & R. Duchene. *Comptes rendus*, Vol. 192, June 22, 1931, pages 1633-1635.

A series of photographs taken showing flame propagation corroborate actual engine tests. (2.10)

Determination of the Limiting Creep Stress. W. Barr & W. E. Bardgett. *Iron & Coal Trades Review*, Vol. 124, Feb. 26, 1932, pages 354-355.

An accelerated test for the determination of a safe limiting creep stress at elevated temperatures is described which gives results within 48 hours while usual methods require months. The test depends on the measurement of the diminishing rate of creep in a stressed test piece by means of a steel weigh-bar so that the creep of the test piece is accompanied by a proportionate decrease in the applied stress. The test piece is heated by a close fitting electric coil. Actual tests are described. A table giving the limiting creep stresses of several steels between 400 and 600° C. and their analyses is added. Ha (2.10)

JOURNAL OF SCIENTIFIC INSTRUMENTS

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Volume IX OCTOBER, 1932 Number 10

The English journal devoted to scientific instruments, their principles, construction and use. Essential to all up-to-date designers, makers and users of instruments.

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Determination of Corrosion Resistance of Metallic Materials at Elevated Temperatures (Ueber die Bestimmung der Korrosionbeständigkeit metallischer Werkstoffe bei hohen Temperaturen). J. Fritz & F. Bornefeld. *Krupp'sche Monatshefte*, Vol. 12, Aug.-Sept. 1931, pages 237-241.

The method used by Krupp determines the loss of metal under heating of from 120 to 240 hrs. at 500-1300° C. The furnace and procedure used are described and directions for the proper evaluation of the test results are given.
Ha (2.10)

TESTING AND INSPECTION (3)

Physical Testing and Inspection (3.1)

Demonstrating Bridge Stresses by Working Model. *Engineering News-Record*, Vol. 108, March 17, 1932, page 389.

Model developed by F. C. Nesbitt, designing engineer Ohio Highway Department, makes visible the distribution and variation of stresses bridge truss members. CBJ (3.1)

Endurance Tests of Acetylene Welds (Ueber Dauerprüfungen von Azetylen-Schweissungen). Baumgaertel. *Forschungsarbeiten auf dem Gebiete des Schweissens und Schneidens mittels Sauerstoff und Azetylen*, Series 6, 1931, pages 27-37.

Descriptions of the bending machines of Schenck, Foeppl and of the Woehler-Institute, that of Foeppl-Heydekampf and the bending-oscillating machine of the Maschinenfabrik Augsburg-Nürnberg. Ha (3.1)

A Simple Mortar Tester. H. Berridge. *Engineering*, Vol. 132, Nov. 6, 1931, page 597.

Tester uses a ⅝ in. cube of mortar which sets hard in 2 days giving results comparable with those obtained under actual conditions of use. As the test piece is small, the crushing load is low so that a spring is used instead of weights and levers or hydraulic pressure. Apparatus is 2 ft. 6 in. long by 3 in. by 3 in. LFM (3.1)

The Measurement of the Quality of Rubber Compounds by Means of Abrasion Tests. H. A. Depew. *The Rubber Age*, Vol. 30, 1932, Feb. 10, pages 397-400, Feb. 25, pages

The work of the Abrasion Testing Sub-Committee of the American Society Testing Materials is reviewed and relations between tensile strength, tension tests and abrasion resistance discussed and explained. Curves showing such relations are reproduced and machines for testing rubber described. Ha (3.1)

Universal Testing Machine. Toledo Precision Devices Co. *Instruments*, Vol. 5, March 1932, page 82.

Illustrated description of new machine in which the force measured is applied by a hydraulic press and transmitted through the test piece. Automatic springless pendulum type counterbalancing mechanism. MFB (3.1)

Universal Testing Machine. Tinius Olsen Testing Machine Co. *Instruments*, Vol. 5, March 1932, page 79.

Illustrated description of new model. Has a gear drive with 4-speed automotive gear box. Gears are always in mesh, and can be shifted without operating neutral control lever. 2-pointer dial. MFB (3.1)

Rubber Abrasive Resistance Tester. American Instrument Co. *Instruments*, Vol. 5, April 1932, page 107.

Describes new machine for accelerated wear test: 6 in. diam. motor-driven abrasive-covered drum; rev. counter; dial gage reads wear to 0.001 in. MFB (3.1)

Universal Testing Machine. Steel City Testing Laboratory. *Instruments*, Vol. 5, June 1932, page 164.

Illustrated description of new model with pulling heads both adjustable, pendulum dynamometer load-indicating dial and autographic attachment. MFB (3.1)

Torsion Testing Machine. (Machine d'essai à la torsion.) R. Guillery. *Revue de Métallurgie*, V. 29, Jan. 1932, pages 52-54.

Detailed description of machine particularly suitable for testing wires of different lengths and at elevated temperature. Consists of a horizontal bench supporting a movable tail stock for holding the end of the wire and the mechanism by which torsion is applied to its other end. The torque is created by rotating the wire clamp against the tension of oil damped spring. Proper means are provided for automatic drawing of torque-angle of torsion diagram and counting of revolutions. JDG (3.1)

Apparatus for Long Period Temperature-Stress Tests on Metals. W. H. Hatfield, G. Stanfield, J. Woolman & N. B. McGregor. *Journal of Scientific Instruments*, Vol. 9, May 1932, pages 150-153.

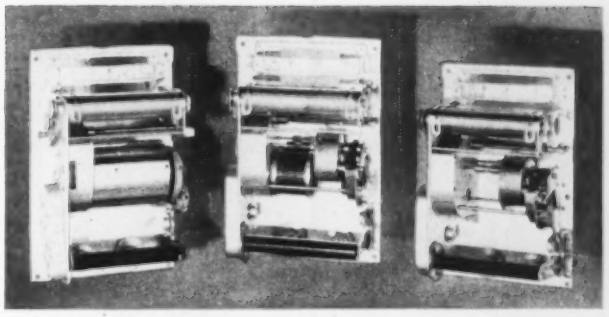
An apparatus for high temperature mechanical testing suitable for accurate determination of creep and allied effects is described and illustrated, and the order of sensitivity indicated. The apparatus includes a sensitive optical extensometer reading to 0.3 millionths in./in. The test piece has an 8 in. gage length. A method of controlling the temperature of the specimen to ± ¼° C. in an electric resistance furnace makes use of a Pt resistance coil placed in the furnace, and which forms part of a Wheatstone Bridge and through a control indicator and relay operates the adjustment of the furnace current to compensate for minor fluctuations from various causes. The loading device is a simple lever system equipped with knife edges, the load being applied by means of a screw placed under the 20:1 lever arm. WAT (3.1)

A New Testing Machine for the Determination of Alternating Strength for Revolving Bending Stress (Neue Prüfmaschine zur Bestimmung der Wechselfestigkeit für umlaufende Biegung). W. Schwinning & E. Dörgeloh. *Zeitschrift für Metallkunde*, Vol. 23, June 1931, pages 186-188.

Describes a new testing machine developed for determination of repeated stresses on wires from 18 to 5 mm. in diameter. Contains 7 references to previous work along similar lines. EF (3.1)

Model Tests Confirm Design of Hoover Dam. J. L. Savage and Ivan E. Hauk. *Engineering News-Record*, Vol. 108, April 7, 1932, pages 494-499.

The deflections and strains of a plaster-celite model under mercury loading were measured with high precision. The results obtained confirm the design analysis closely. Methods of loading, measuring deflections, interpreting data, etc. are well presented. CBJ (3.1)



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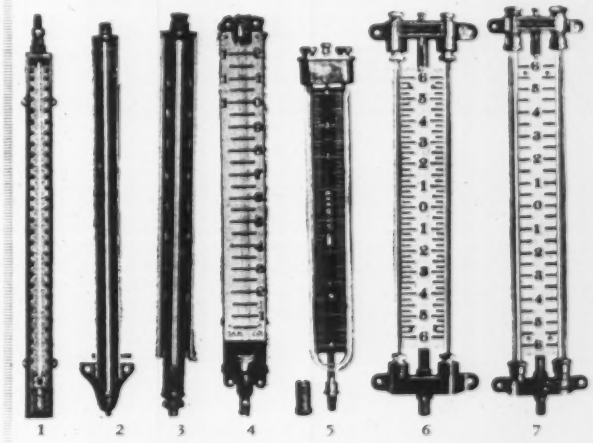

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Maintenance Testing and Inspection (3.3)

Apparatus for the Testing of Railroad Tracks. (Gerät zur Geleisuntersuchung.) K. W. GEISLER. *Zeitschrift Verein deutscher Ingenieure*, Vol. 75, Aug. 22, 1931, pages 1084-1085.

A fast rotating disc on an isolated axis is running over the rail head and at the side of the latter another little disc runs along. As long as the deviations of the rail from the straight do not exceed the admissible value this disc remains on the isolated part. If the deviation becomes larger contact with the metal is made and a tank with paint opened at the same time from which paint is blown against that defective part of the rail which then is easily recognizable for repair. This device is used once a year on the Belgian State Railways. Ha (3.3)

Determination of the Frequency of Inspection for the Maintenance and Checking of Alternating-Current Meters. (Détermination de la fréquence des visites d'entretien et de vérification des compteurs á courant alternatif.) P. MAURER. *Revue Générale de l'Électricité*, Nov. 14, 1931, pages 806-809.

To determine the frequency of inspection, it is necessary to know, on one hand, the costs of such inspection, and, on the other, the gains to be realized from the adjustment of the meters inspected. Develops principles for arriving at the optimum frequency of inspection. Presents data in graphical form. MS (3.3)

ELECTRICITY AND MAGNETISM (4)

Electrical Properties, Tests, Measurements, and Measuring Instruments (4.1)

Watthour Meter. WESTINGHOUSE ELECTRIC & MFG. CO. *Instruments*, Vol. 5, July 1932, page 181.

Brief illustrated description of new watthour meter, a feature of which is improved general design of electromagnet, assuring better performance on variable voltage and temperature. MFB (4.1)

Measurement of Ground Resistances. (Messung von Erd-Widerstanden.) JOS. KROENERT. *Archiv Technisches Messen*, Vol. 1, No. 7, Feb. 23, 1932, section V 35192-1, pages T2-3.

Definitions and methols of grounding to get the required low resistance are described. The following values are given (all in ohm-cm.): Sea water, about 0.1×10^3; boggy ground, 1 to 5; clay, 2-30; wet sand, 10-60; dry sand, 50-100; gravel, 20 to 400×10^3; stony ground, 50 to 800; rock, 10^6 to 10^{12}. Several methods requiring two measurements, or only one, are described, most of them are bridge or megger methods. 11 references. Ha (4.1)

Problems of Remote Measurements. (Aufgaben der Fernmessung.) GEO. KEINATH. *Archiv Technisches Messen*, Vol. 1, No. 7, 1932, Feb. 23, section V 380-1, page T5.

The principles and requirements of remote measuring systems are discussed and the transmission of the measured values is described for small distances (to 3 km.), for medium distances (about 20 km.), and for long distances (to 1000 km.) Ha (4.1)

Remote Measuring with Measuring Dynamo. (Ferumessung mit Messdynamo). GEO. KEINATH. *Archiv Technischer Messen*, Vol. 1, Feb. 23, 1932, section V 3833-1, pages T6-7.

This type of transmission uses a motor (meter) which rotates proportionally to or in any definite function of the quantity to be measured and transmitted, and drives a little magneto. A historical sketch of the development of the method is given and the theory and practical arrangement of motor and magneto as metering dynamo explained. The arrangement permits also the summation of several quantities. Ha (4.1)

Measurement of Corona Losses. (Messung der Korona-Verluste.) H. BARTHELT. *Archiv für Technisches Messen*, Vol. 1, No. 7, Feb. 23, 1932, section V 3446-1, page T1.

The measurement of losses due to corona on transmission lines represents a measurement at very high voltages with very low power factor; they can be determined directly with the Schering-bridge method which, however, does not take into account the influence of higher harmonics, or with a dynamometer, which is rather dangerous, or indirectly with mirror galvanometer or dynamometer over instrument transformer. The methods and their respective advantages are explained. 13 references. Ha (4.1)

Short-Circuit Measurement. (Windungsschluss-Messung.) W. GEYGER. *Archiv Technisches Messen*, Vol. 1, No. 7, Feb. 1932, section V 3526-1, page T4.

The routine tests for short-circuit of windings in coils are described; they are made by measuring the current, or an induced voltage, or by differential or resonance measurement. Ha (4.1)

Electrical Measuring Devices and Applications (4.2)

Alternating Current Compensators with Complex Comparison Voltage (Wechselstrom-Kompensatoren mit zusammengesetzter Vergleichsspannung). W. GEYGER. *Archiv für Technisches Messen*, Vol. 1, Feb. 23, 1932, section F 94-1, pages T 13-14.

Under complex compensation are understood apparatus which compensate the voltage to be measured by a comparison voltage which can be changed in magnitude and phase and is composed of two partial voltages, with a phase difference of 90°, which are changed until the zero instrument does not indicate any current. Electrical arrangements to achieve this end are described. Ha (4.2)

Electrical Telemetering. H. OLKEN. *Instruments*, Vol. 5, March 1932, pages 66, 74.

Systems are explained, illustrated, classified into 4 basic principles of electrical translation: variation of electrical quantities in a circuit joining receiver and transmitter, the null or balance principle, the principle of synchronization, and the selection principle. Points most considered about each system are: (1) economy of transmission line cost by utilizing available power or communication lines; (2) transmission free from line characteristic fluctuations or voltage changes of transmission power supply; (3) means for sending one indication to several points, or several indications to one point, and (4) means for integrating the readings received. MFB (4.2)

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Telemetering—A Correction. *Instruments*, Vol. 5, April 1932, pages 91-92.

Pertains to above and refers to Leeds & Northrup telemetering circuits. MFB (4.2)

Report on Telemetering, Supervisory Control and Associated Communication Circuits. Prepared by a Subcommittee of the Committees on Automatic Stations and on Instruments and Measurements, A. I. E. E. *Paper presented at Summer Convention of American Institute of Electrical Engineers*, June 20-24, 1932, 24 pages.

Report is arranged in 3 sections as per title. The section on telemetering, to which the most space is devoted in Report, covers only electrical translating means of remote measurement and integration. "The use of [electrical] telemetering in non-electrical fields . . . promises to assume a position comparable in importance to that occupied by telemetering in the electrical field." Types of systems which Sub-committee recommends to Institute for official classification: (1) current, (2) frequency, (3) impulse, (4) position, (5) voltage. These terms are self-explanatory except "position" which employs relative phase position between, "or the magnitude relation of, two or more electrical quantities . . ." No frequency type of telemetering system included in Report; at least one is in operation but none is on the market as commercial system, it is said. Characteristics of all existing commercial systems are presented in a fair and uniform manner, in a table covering 9 pages. 33 systems (incl. duplications) offered by 17 firms are analyzed point by point: description, method of operation ("type"), character of indication provided, performance (speed from zero to full-scale, lag components, probable error under normal operating conditions, power requirements, etc.), characteristics affecting line transmission (11 items), interference and protection features (5 items), etc. Reasons for and explanations of various points are given in preliminary notes; also copious footnotes elaborating tabulated statements pertaining to individual commercial systems. The 33 systems thus thoroughly analyzed are "standard" (by which, no doubt, "regular" is meant) and no attempt was made to list the numerous "variations" (modifications) commercially available and frequently installed, but despite this lacuna and 24 "information not available" gaps in the table of characteristics, this Telemetering section of the Report is a much-needed compendious quick-reference for present and prospective users of electrical remote-reading systems. It is not a treatise as are some reports of instruments committees of, say, the A. S. M. E., but on the other hand presents nearly all the data concerning all known commercial makes—which the A. S. M. E. Instrument Codes is not designed to do. In saying "nearly all," we wish to point out a serious omission, to wit, the date when each system was placed on the market. Though undoubtedly prompted by a desire for impartiality, it may give an opposite impression, as in the case of the Bristol Co.'s original principle which has been copied in other systems. The other 2 Sections of the Report are less compendious; one notes, *e.g.*, that Howe Supervisory System is not included. The "Selected" bibliography is actually comprehensive. MFB (4.2)

Watt-Hour Meter and Lamps as Phase-Rotation Indicator. L. W. Wyss. *Power*, Vol. 75, March 29, 1932, page 479.

A phase-rotation indicator can be constructed by connecting 2 lamps to the potential transformer leads and an alternating-current watt-hour meter. The wiring diagram is given. AHE (4.2)

◈ ◈ ◈

The Engine Indicator

(Continued from page 261)

The parts of the apparatus are shown in Figs. 75e and 75f. The pressure measuring parts are shown in Fig. 75f. The gas pressure acts upon the piston K which is loaded through the rod St by a stiff diaphragm P. This latter is fixed into the housing by means of ring R.

The diameter of the diaphragm is 40 mm. (about 1-9/16 in.); its thickness is, for high pressures, up to 600 lbs./in.^{2}, 1 mm. for low pressures, up to 50 lbs./in.^{2} about 0.25 mm. Kurtz and Oestrich calculate the natural frequency of vibration, under the assumption of constraint at the edge: $\omega_1 = {}^1 26200\ \text{sec}^{-1}$ for the stiff diaphragm, and $\omega_2 = 3520\ \text{sec}^{-1}$ for the weak diaphragm. Under the assumption of free support at the edges the natural frequencies are: $\omega_1 = 16600\ \text{sec}^{-1}$ and $\omega_2 = 2220\ \text{sec}^{-1}$ respectively.

The actual frequency will probably lie between these calculated limiting values, which show the suitability of the pressure measuring system for high speed engines.

The diagram is measured under the microscope, or better, it is photographed, at a known magnification, by microphotographic means. Such a microphotogram is shown in Fig. 75g, taken from a one-cylinder engine running at 1500 r.p.m. The dimensions given illustrate the extreme smallness of the diagram in its original form, as scratched on the glass. The diagram height is 0.57 mm. (about 0.0225 in.)

The indicator is calibrated with compressed air, with the aid of a master gage or by dead-weight methods.

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Foxboro Co.
Tagliabue Mfg. Co., C. J.

Pressure & Vacuum
Bailey Meter Co.
Bristol Company
Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.
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Pyrometer
Bailey Meter Co.
Bristol Company
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Foxboro Co.
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Bristol Company
Brown Instrument Co.
Foxboro Co.
Weston Elec. Inst. Corp.

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Bristol Company
Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

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Bristol Company
Brown Instrument Co.
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Bristol Company
Brown Instrument Co.
Foxboro Co.
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Bailey Meter Co.
Bristol Company
Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

Valve—Motor Operated
Bristol Company
Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

Voltage A.C.
Ward Leonard Elec. Co.

Water Level
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.

COUNTERS—Ratchet, Magnetic
Veeder-Root, Inc.

Revolution
Baldwin-Southwark Corp.
Bristol Company
Brown Instrument Co.
Veeder-Root, Inc.

Stroke
Baldwin-Southwark Corp.
Bristol Company

COUPLING TRANSFORMERS
General Radio Company

CREEP TESTER
Baldwin-Southwark Corp.
Alfred Suter

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Tagliabue Mfg. Co., C. J.

DAMPING TESTER
Baldwin-Southwark Corp.

DEFORMETER (Beggs)
Baldwin-Southwark Corp.

DEMAND METERS
Gas
Foxboro Company
Electric
General Electric Co.

DIMMERS
Ward Leonard Elec. Co.

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Bausch & Lomb Optical Co.

DIVIDING MACHINES
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Gaertner Scientific Corp.

DRAFT GAGES—see Gages

DYNAMIC BALANCING EQUIP.
Alfred Suter

DYNAMOMETERS
Weston Elec. Inst. Corp.

EARTH CURRENT METERS
Rawson Elec. Inst. Co.

EBULLIOMETERS
Tagliabue Mfg. Co., C. J.

ELECTRIC TELEMETER
Baldwin-Southwark Corp.

ELECTRIC WAVE FILTER SECTIONS
General Radio Company

ELECTROMETERS
Rubicon Co.

ELECTRONIC METERS
Rawson Elec. Inst. Co.

ENGINE INDICATORS
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Morey & Jones, Ltd.
Indicating & Recording
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Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.

FLUE GAS ANALYZERS
Hays Corporation

FLUXMETERS
Rawson Electrical Instr. Co.

FREQUENCY METERS
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General Electric Co.
Weston Elec. Inst. Corp.
Controlling
Recording
Bristol Company
Standards
General Radio Co.

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Defender Automatic Regulator Co.

FUEL FLOW INDICATOR
Defender Automatic Regulator Co.
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Bristol Company
Defender Automatic Regulator Co.
Taylor Instrument Companies

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Instrument
Littelfuse Laboratories

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GAGES
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Bristol Company
Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
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R. Y. Ferner Co.
Comparator
R. Y. Ferner Co.
Cylinder
R. Y. Ferner Co.
Deformation
Baldwin-Southwark Corp.
Depth
Dial
R. Y. Ferner Co.

Differential Pressure
Bailey Meter Co.
Brown Instrument Co.
Foxboro Co.
Hays Corporation
Morey & Jones, Ltd.
Tagliabue Mfg. Co., C. J.
Draft
Bailey Meter Co.
Bristol Company
Brown Instrument Co.
Ellison Draft Gage Co.
Foxboro Co.
Hays Corporation
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
Drill
Bausch & Lomb Optical Co.
Flow
Bailey Meter Co.
Morey & Jones, Ltd.
Grinding
Liquid Level
Bailey Meter Co.
Bristol Company
Brown Instrument Co.
Ellison Draft Gage Co.
Foxboro Co.
Morey & Jones, Ltd.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
Loss of Head
Bailey Meter Co.
Bristol Company
Brown Instrument Co.
Foxboro Co.
Morey & Jones, Ltd.
Pitch Diameter
R. Y. Ferner Co.
Pocket
Pressure
Bailey Meter Co.
Bristol Company
Brown Instrument Co.
Foxboro Co.
Alfred Suter
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
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Bailey Meter Co.
Bristol Company
Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
Pressure & Vacuum
Bailey Meter Co.
Bristol Company
Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
Profile
Bausch & Lomb Optical Co.
Rain
Taylor Instrument Companies
Recording—Distance
Bailey Meter Co.
Bristol Company
Brown Instrument Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
Strain
Baldwin-Southwark Corp.
Alfred Suter
Tester
Baldwin-Southwark Corp.
Thickness
R. Y. Ferner Co.
Vacuum
General Electric Co.
Volume
Brown Instrument Co.
Foxboro Co.
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Bailey Meter Co.
Bristol Company
Brown Instrument Co.
Foxboro Co.
Wind
Bristol Company
Brown Instrument Co.
Taylor Instrument Companies

GALVANOMETERS
Brown Instrument Co.
General Radio Co.
Rawson Elec. Inst. Co.
Rubicon Company
Weston Elec. Inst. Corp.

GAS ANALYTICAL METERS
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Electrical
Brown Instrument Co.

GAS LEAK INDICATORS
Taylor Instrument Companies

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Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.

GOVERNORS
Pressure
Bailey Meter Co.
Bristol Company
Brown Instrument Co.
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Tagliabue Mfg. Co., C. J.

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Alfred Suter

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Rubicon Company
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Taylor Instrument Companies

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HYDROGEN ION METERS
Indicating
Rubicon Company

HYDROMETERS
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Taylor Instrument Companies

HYGROMETERS
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Foxboro Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

ILLUMINOMETERS
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IMPACT HARDNESS TESTER
Alfred Suter

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INDICATORS—See Gages

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INSULATION TESTING EQUIPMENT
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Rubicon Company

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Gaertner Scientific Corp.

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General Radio Co.
Rubicon Company

KEYSTROKE COUNTERS (for Typewriters, etc.)
Veeder-Root, Inc.

KILNBOY
Foxboro Co.

LABORATORY RHEOSTATS
Ward Leonard Elec. Co.

LACTOMETERS
Tagliabue Mfg. Co., C. J.
Taylor Instrument Cos.

LENGTH MEASURING MACHINES
R. Y. Ferner Co.
Gaertner Scientific Corp.

LEVELS
Centering
Bausch & Lomb Optical Co.
R. Y. Ferner Co.
Engineer's, Wye, Precision, Prism
R. Y. Ferner Co.
Taylor Instrument Companies

LOCOMOTIVE INDICATORS
Baldwin-Southwark Corp.

MAGNETIC RELAYS
Ward Leonard Elec. Co.

MAGNETOMETERS
Rubicon Company

MANOMETERS
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Brown Instrument Co.
Defender Automatic Regulator Co.
Foxboro Co.
Hays Corporation
Morey & Jones, Ltd.
Alfred Suter

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Rubicon Company

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Weston Elec. Inst. Corp.

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Rubicon Company
Weston Elec. Inst. Corp.

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Gaertner Scientific Corp.

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Bausch & Lomb Optical Co.
Gaertner Scientific Corp.
Alfred Suter
Measuring
R. Y. Ferner Co.
Metallographic
Bausch & Lomb Optical Co.
Petrographical
Bausch & Lomb Optical Co.
Toolmakers'
Bausch & Lomb Optical Co.
Gaertner Scientific Corp.

MICROTOMES
Bausch & Lomb Optical Co.

MILLIAMMETERS
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General Electric Co.
General Radio Co.
Rawson Elec. Inst. Co.
Weston Elec. Inst. Corp.

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Weston Elec. Inst. Corp.

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Weston Elec. Inst. Corp.

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Bristol Company
Foxboro Co.

MOTOR STARTERS
Ward Leonard Elec. Co.

MULTIMETERS
Rawson Elec. Inst. Co.

MULTIPLE PEN RECORDER
Baldwin-Southwark Corp.
Foxboro Co.

MULTIPLIERS
Weston Elec. Inst. Corp.

OHM METERS
General Radio Co.
Rawson Elec. Inst. Co.
Rubicon Company
Weston Elec. Inst. Corp.

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General Electric Co.
Tagliabue Mfg. Co., C. J.
Taylor Inst. Companies

OPERATION RECORDERS
Electrical
Bristol Company
Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.

ORIFICE METERS
Indicating
Bailey Meter Co.
Defender Automatic Regulator Co.
Morey & Jones, Ltd.
Indicating & Recording
Bailey Meter Co.
Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.

ORSAT APPARATUS
Hays Corporation

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Weston Elec. Inst. Corp.

OSCILLOGRAPHS
Baldwin-Southwark Corp.
General Electric Co.
General Radio Co.
Hellige, Inc.

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Hays Corporation
Tagliabue Mfg. Co., C. J.

PANTOGRAPHS
Gaertner Scientific Corp.

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Gaertner Scientific Corp.

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Rubicon Company

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General Electric Co.
Weston Elec. Inst. Corp.

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General Electric Co.

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General Electric Co.

PHOTOMETERS
Gaertner Scientific Corp.
Bausch & Lomb Optical Co.

PHOTO-MICROGRAPHIC EQUIP.
Bausch & Lomb Optical Co.

PHYSICAL TESTING MACHINES
Baldwin-Southwark Corp.
Alfred Suter

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Defender Automatic Regulator Co.
Foxboro Co.

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Foxboro Company
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Brown Inst. Co.
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Bristol Company
Foxboro Co.
Square Root
Foxboro Company

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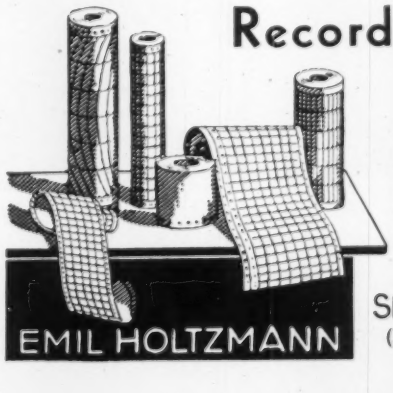
Bausch & Lomb Optical Co.
Gaertner Scientific Corp.
Hellige, Inc.

POSITION RECORDERS
Bristol Company
Foxboro Co.
Tagliabue Mfg. Co., C. J.



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Hays Corporation
Tagliabue Mfg. Co., C. J.
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General Radio Co.
Rawson Electrical Inst. Co.
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Weston Elec. Inst. Corp.
THERMOPILE—Coblenta Type
Eppley Laboratory, Inc.
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Brown Instrument Co.
Defender Automatic Regulator Co.
Foxboro Company
Tagliabue Mfg. Co., C. J.
Taylor Inst. Companies
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Brown Instrument Co.
Defender Automatic Regulator Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.
Mercurial
Bristol Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
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Brown Instrument Co.
Foxboro Co.
Vapor-Tension
Bristol Company
Brown Instrument Co.
Defender Automatic Regulator Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.
Taylor Inst. Companies
Wet & Dry Bulb
Bristol Company
Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
THERMOSTATS
Bristol Company
Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
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Foxboro Co.
Tagliabue Mfg. Co., C. J.
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Brown Instrument Co.
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Foxboro Co.
Tagliabue Mfg. Co., C. J.
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Rawson Elec. Inst. Co.
Rubicon Company
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Baldwin-Southwark Corp.
TORSION MACHINES
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General Electric Co.
General Radio Co.
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Gaertner Scientific Corp.
Pocket
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Rubicon Company
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Hellige, Inc.
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Defender Automatic Regulator Co.
Hays Corporation
Morey & Jones, Ltd.
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Brown Instrument Co.
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Tagliabue Mfg. Co., C. J.
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Brown Instrument Co.
Defender Automatic Regulator Co.
Foxboro Co.
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Defender Automatic Regulator Co.
Foxboro Company
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
Electrically Operated
Bristol Company
Brown Instrument Co.
General Electric Co.
Reducing
Bailey Meter Co.
Tagliabue Mfg. Co., C. J.
Regulating
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Defender Automatic Regulator Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
Safety, Fuel Shut-off
Tagliabue Mfg. Co., C. J.
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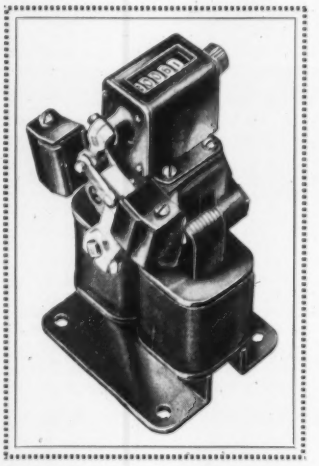

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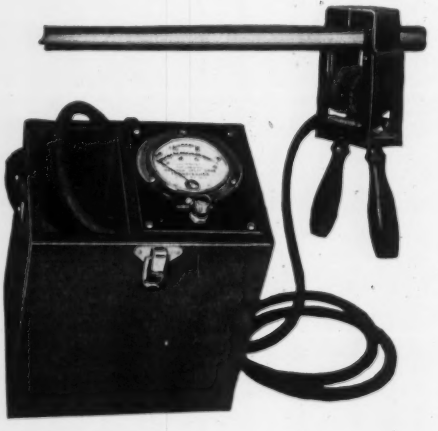

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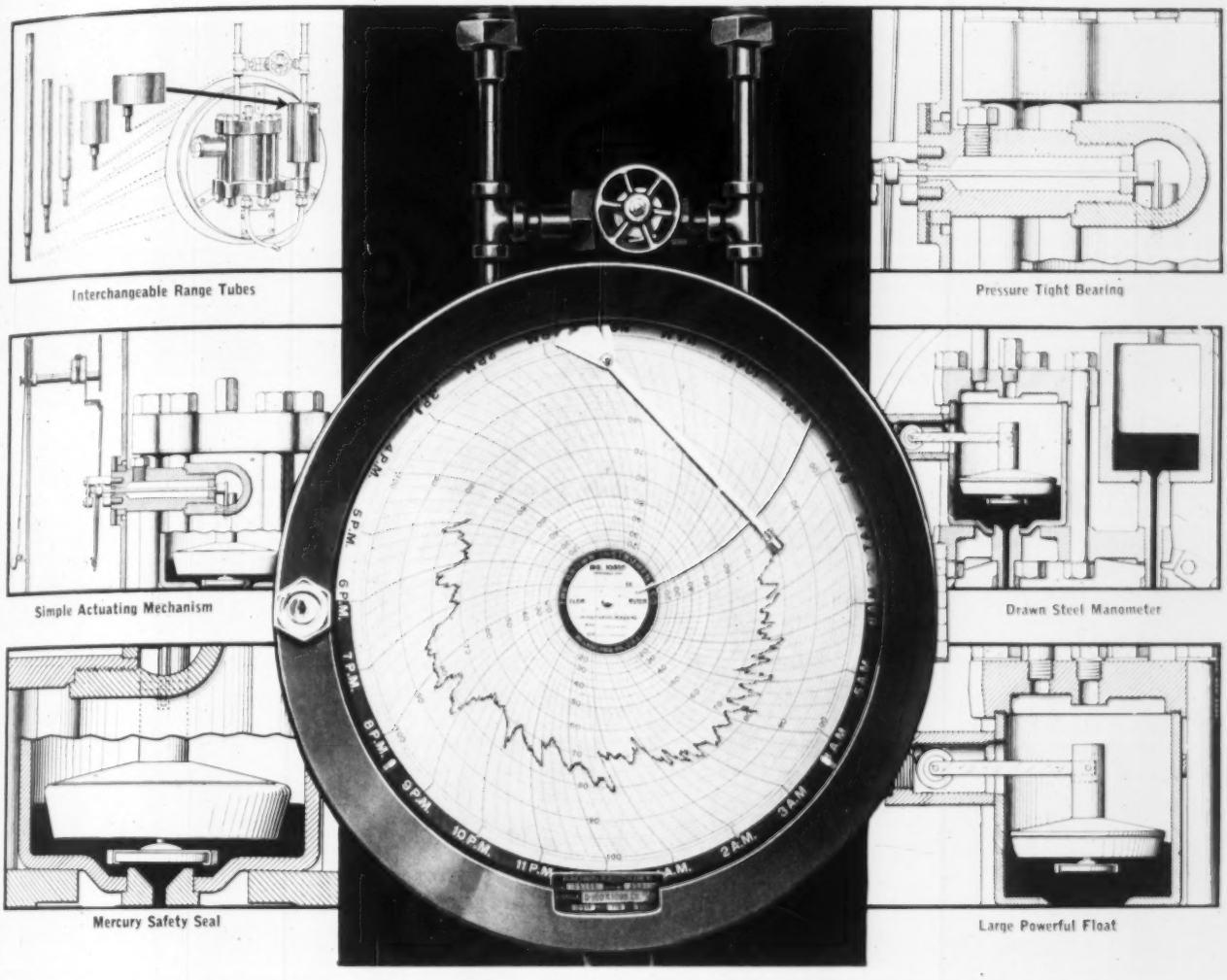

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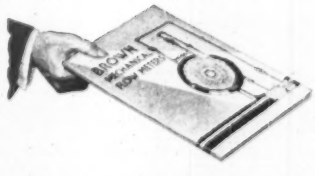

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